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56th Annual Meeting

AUSTIN, TEXAS, June 14–18, 1948

Host

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Charles Ellison MacQuigg, President 1947–48

Charles Ellison MacQuigg was born in Ironton, Ohio, January 19, 1885. He received the E.M. in 1909, and later the honorary degree Eng. Dr. from Clarkson College of Technology. He was civil engineer on the Santa Fe Railway, 1909–10; assistant engineer of tests, Anaconda Copper Mining Co., 1910–12; head, department of metallurgy at The Pennsylvania State College, 1912–17; engineering research and commercial development, Union Carbide and Carbon Co., 1919–37; Dean, College of Engineering, The Ohio State University since 1937, also Director Engineering Experiment Station.

Dean MacQuigg has been Lt. Colonel, Ordnance Reserve, U. S. Army; Regional Adviser ESMWT; Chairman, Ohio Water Resources Board; Member, Executive Committee, Engineering Division, Association of Land Grant Colleges and Universities; Metallurgical Advisory Committee, National Research Council with various assignments on NDRC; Ohio Farm Chemurgic Committee; Newcomen Society of England; Sigma Xi, Tau Beta Pi, AIMME, ASTM, ASM, ASME, AAAS; Fellow, Ohio Academy of Science; Recipient of the James Turner Morehead medal of the International Acetylene Association; the inventor of metallurgical patents, and author of many technical papers.

Dean MacQuigg became a member of the Society in 1937, was a member of the Council 1939–40, and Vice President 1942–43.

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Lamme Award—Warren Kendall Lewis

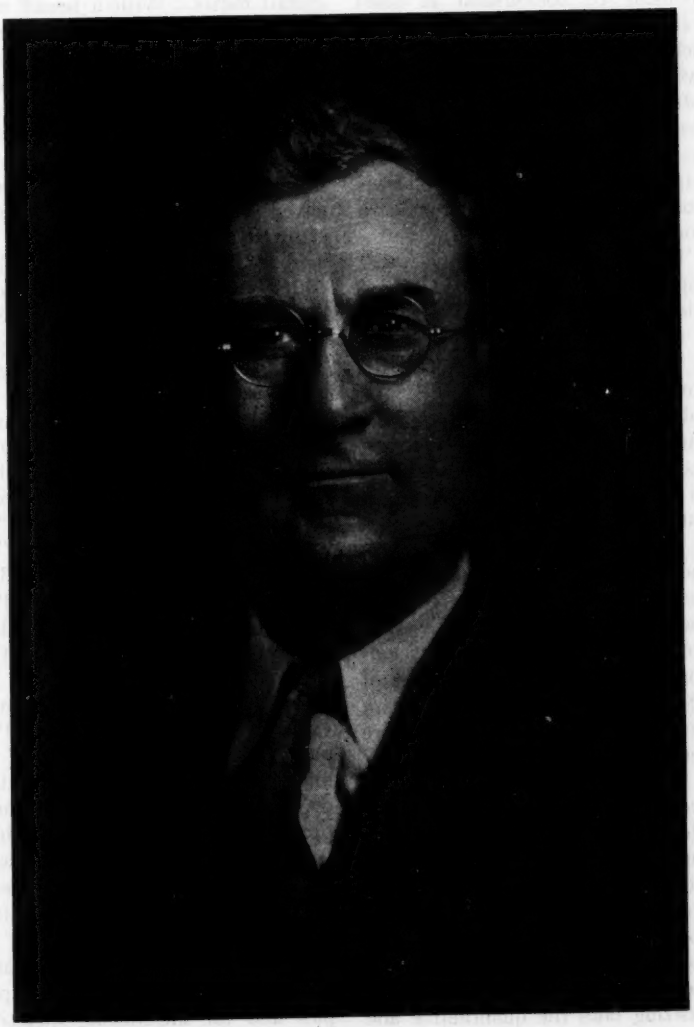
To Warren Kendall Lewis for his great part in the development of chemical engineering in its modern quantitative aspects; for his contributions to its fundamental concepts, and to their many important applications in chemical industry; for the vision, inspiration, and sound methods imparted to his students through the originality and clarity of his thought and writing and through his personal vigor and enthusiasm.

WARREN KENDALL LEWIS, twentieth Lamme medalist of this Society, was born at Laurel, Delaware on August 21, 1882. He was graduated from the Massachusetts Institute of Technology with the degree of Bachelor of Science in Chemical Engineering in 1905 and received his Doctor of Philosophy degree in Chemistry from the University of Breslau (Germany) in 1908. The honorary degree of Doctor of Science was bestowed upon him by the University of Delaware in 1937 and that of Doctor of Engineering by Princeton University in 1947.

Following his graduation from M.I.T., Lewis remained there for a year as Assistant in Industrial Chemistry and returned as Research Associate in Applied Chemistry upon completion of his graduate work in Germany. In 1909, he became chemist for the W. H. McElwain Company but the next year was appointed Assistant Professor at M.I.T. In 1912 he became Associate Professor and since 1914 has been Professor of Chemical Engineering at that institution. From 1920 to 1929, he was head of the Department of Chemical Engineering. During the first World War, he was on leave with the War Department's Chemical Warfare Service in charge of the coordination of research on gas defense. In World War II, in addition to carrying temporary responsibility for the Chemical Engineering Department at M.I.T., he acted as consultant for the National Defense Research Committee and served on several advisory boards for the Manhattan District.

His major consulting work has been with the Standard Oil Development Company, Humble Oil and Refining Company, Goodyear Tire and Rubber Company, Eastman Kodak Company, Freeport Sulphur Company, and the General Electric Company, as well as with a number of other large companies through the Institute's School of Chemical Engineering Practice.

Dr. Lewis' contributions to the theory and practice of chemical engineering stem from basic research and interpretation which he has initiated or guided in such fields as the flow of heat, the fundamental properties of fluids, their particular significance to hydrocarbons, the mathematical treatment of rectification, and the theory of vulcanization of rubber. His work has reaffirmed the utility of the generalized "equation" of state and has developed this theory as a working engineering tool through graphical manipulation of the relationships involved. It has demonstrated the mechanisms of interphase diffusion as they occur in rectification, extraction, absorption, drying and similar processes,



WARREN KENDALL LEWIS

TWENTIETH RECIPIENT OF LAMME AWARD

and has led to understanding of the mechanisms of combustion in solid fuels and of generation of producer gas.

Such fundamental work has led to noteworthy accomplishments in many industries such as petroleum, rubber, cellulose, and amorphous materials generally. Two examples of widespread industrial significance stand out. Lewis initiated the introduction of modern methods of distillation into the petroleum industry, where he proved that principles previously used in other industries could be adapted to the far more complex structure of petroleum. With Gilliland and others, he carried out underlying pioneering work and played a responsible part in the development of the fluid catalyst cracking process. The original concepts upon which this process is based were promulgated in 1938. First utilized on a large scale during the war for the production of aviation gasoline and synthetic rubber, this process now is also largely used for high quality, low cost motor gasoline. The plants employing it represent an investment of over $200,000,000 and additional plant is planned to provide 40 per cent more capacity within the next three years.

In 1936, the Perkin Medal for achievement in applied chemistry was awarded to Dr. Lewis by the American Section of the British Society of Chemical Industry.

In his teaching, Dr. Lewis constantly has sought effective ways to stimulate intellectual initiative in his students. In the classroom, through examples emphasizing both the quantitative and the qualitative elements in a problem, students are forced into situations where they must do analytical thinking of their own. Laboratory work is made a genuine investigative procedure and the research point of view is developed even in undergraduates through a required thesis. With a broad interest in and appreciation for physics and chemistry, he has taught vigorously the application of pure science to the solutions of the problems of chemical industry. His determination in overcoming obstacles in converting theory into practice and his personality and magnetism have led his students and younger associates to absorb some measure of his methods and have fired them with his enthusiasm and vision. His work in the development of the M.I.T. School of Chemical Engineering Practice has been a major contribution to engineering education.

The breadth of his interests and his capacity are well illustrated by the scope of his publications. In addition to a large number of technical papers, his publications include the book, "Principles of Chemical Engineering," with Walker and McAdams (1923 and 1927) and also with Gilliland (1937); "Industrial Stoichiometry," with Radasch (1926), and "Industrial Chemistry of Colloidal and Amorphous Materials," with Squires and Broughton (1942). The importance of "Principles of Chemical Engineering" as a milestone of progress can hardly be overestimated. It conveyed to the new profession the results of pioneering investigation. It gave the first adequate concept of the scope of the profession, and it defined and applied the fundamental engineering principle. Dr. Lewis' originality and genius for discovering and elucidating basic principles and for introducing quantitative treatment into a subject which had previously been purely qualitative shines throughout this work.

Dr. Lewis is a member of the American Chemical Society, Society of Chemical Industry, American Institute of

Chemical Engineers, American Institute of Mining and Metallurgical Engineers, American Leather Chemists Association, American Academy of Arts and Sciences, National Academy of Sciences, and an honorary member of the Institute of Chemical Engineers of Great Britain.

In 1909, he married Rosaline Denny Kenway. They have two sons and two daughters and their home is at 85 Lombard Street, Newton, Massachusetts.

RECIPIENTS OF A.S.E.E. LAMME MEDAL

1928—George Fillmore Swain
1929—Irving Porter Church
1930—Charles Felton Scott
1931—Dugald Caleb Jackson
1932—Arthur Newell Talbot
1933—Dexter Simpson Kimball
1934—Edward Rose Maurer
1935—William Elgin Wickenden
1936—Herman Schneider
1937—Frederick Eugene Turneaure
1938—Robert Lemuel Sackett
1939—Stephen P. Timoshenko
1940—Audrey A. Potter
1941—Anson Marston
1942—Roy Andrew Seaton
1943—Thomas Ewing French
1944—Hardy Cross
1945—Harry Parker Hammond
1946—Robert Ernest Doherty
1947—Warren Kendall Lewis

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George Westinghouse Award—Benjamin Richard Teare, Jr.

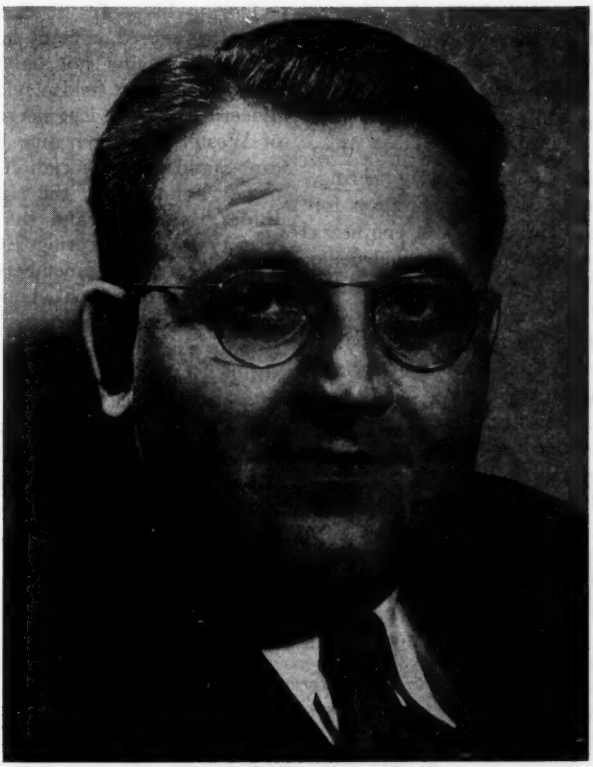
To Benjamin Richard Teare, Jr.—for his invaluable work in the development of courses in engineering analysis; for his spirited support and ready cooperation in every worthwhile effort toward betterment of engineering education; and for the bracing influence on his students and fellow workers of the power of his attack on every new problem, the second George Westinghouse Award in Engineering Education is made.

Benjamin Richard Teare, Jr., known as "Dick" to a host of friends in education and in industry, was appointed to a full professorship at Carnegie Institute of Technology at the age of thirty-two. Five years later he became Buhl Professor and Head of the Department of Electrical Engineering. He has gained a national reputation for his pioneering work in the development and coordination of engineering courses.

In the field of engineering education, Dr. Teare has written important papers on Engineering Education. Notable among these are "Teaching Methods in Engineering Analysis" (JOURNAL OF ENGINEERING EDUCATION, Vol. 35, June 1945) and "Planning the Professional Aspects of Humanistic and Social Courses" (JOURNAL OF ENGINEERING EDUCATION, Vol. 37, December 1946). These papers discuss the development of power of analysis in students by means of engineering analysis courses set up specifically to this end and also by means of humanistic and social courses. The second paper uncovers valuable possibilities for further improvement of engineering education. Dr. Teare has also contributed to the committee work of the American Society for Engineering Education. He participated in the "Report of the Committee on Engineering Education After the War" which has proved to be a sound blueprint for the post-war adjustment of engineering colleges.

These important contributions to educational philosophy have made Dr. Teare no less warm to the human problems of hundreds of students in his department. Of his relationship with Dr. Teare one student writes, "His course in engineering analysis was inspiring, both for the wealth and depth of the material he presented, and for the force of his personality. He spends his time freely discussing the student's program and plans for the future; makes adjustments in special cases and seeks, by arousing enthusiasm for all subjects, to keep our interests well-rounded. Beyond all this he gives friendly personal advice which proves him to be as fine a man as he is an educator."

Dr. Teare's scholarly achievement is by no means confined to the development of educational methods. He is continuously active and has gained wide recognition in engineering research. Perhaps the most important of his engineering papers are "Skin Effect in Bimetallic Conductors" (*A.I.E.E. Transactions* 1943) which won national and district A.I.E.E. prizes in 1943 and "Theory of Hyste-



BENJAMIN RICHARD TEARE, JR.

resis-Motor Torque" (*A.I.E.E. Transactions* 1940) which was given honorable mention by the A.I.E.E.

Dr. Teare, who was born on January 12, 1907 in Menomonie, Wisconsin, received his B.S. degree in Electrical Engineering (1927) and his Master's degree (1928) at the University of Wisconsin. In the fall of 1929, he joined the General Electric Company at Schenectady as a student in the Advanced Course in Engineering and continued for four years with the educational program while he obtained practical experience in many departments, including Testing, Research, Alternating Current Engineering, Central Station Engineering, and Engineering General. In 1931 he became supervisor of the electrical engineering section of the Advanced Courses in which he had started as a student two years before. At the end of two more years' work at Schenectady, Dr. Teare decided to enter the teaching field and accepted an instructorship in electrical engineering at Yale to work for his doctorate. He was promoted to as-

sistant professor of electrical engineering in 1934 and received his Doctor of Engineering degree in 1936. While getting his first experience in academic education at Yale, he was in close contact with Dr. Robert E. Doherty, then Dean of the School of Engineering, from whom he gained inspiration for many of his ideas on how engineers should be taught so that they develop to the utmost their capacity to think and to solve problems in an orderly way and above all so that they assume their proper responsibilities in society.

The war years found Dr. Teare serving as an electrical engineer in the Naval Ordnance Laboratory and working on research problems for the National Defense Research Committee, the Office of Scientific Research and Development, the Army Air Forces, and the Office of Naval Research.

During his years at Carnegie, Dr. Teare has served on many outside committees involving not only organizations in his own field of electrical engineering, but the Engineering Society of Western Pennsylvania, the American Standards Association, the Carnegie Foundation, the Institute of Radio Engineers, and the American Society for Engineering Education.

Dr. Teare holds membership in the following professional, honorary, and social societies: American Society for Engineering Education, American Institute of Electrical Engineers, Institute of Radio Engineers, Instrument Society of America, Sigma Xi, Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi, and Sigma Phi Epsilon. In 1932 he married Isabel Olbrich and they have one daughter. The Teares reside at 120 N. Homewood Avenue, Pittsburgh, Pennsylvania.

RECIPIENTS OF GEORGE WESTINGHOUSE AWARD

1946—James Norman Goodier
1947—Benjamin Richard Teare, Jr.

Turning Points

By CHARLES E. MACQUIGG
President of the Society

Turning points seem to occur so consistently and naturally in the careers of individuals and nations that we take them as a matter of course and sometimes they may even pass unnoticed at the moment. May they not also occur in the life of a Society like ours? These changes are harder to visualize in the case of a nation or society than in the affairs of an individual. With national life, only in sufficiently long retrospect is one able to say, "That trend started after the era of railroad expansion" or "This was the result of the automobile," and so on.

Possibly societies like ours undergo more or less abrupt shifts at least in their environments. While not as clear-cut as those attending the "inflection points" in the life of the individual, which is accented with some new emphasis in responsibilities, or change of residence or occupation, nevertheless there may be arrivals at periods in human destiny which must perforce bring new patterns of thought, or mass behavior which must in turn register effects on the life and objectives of an association. Certainly our Society was born at the time and place when the new era of electrification was coming into being. The World's Fair at Chicago may be looked upon as a great preview of a new era in our national existence. Then it was that countless thousands of us saw arc-lights for the first time—or the "naphtha" launch—or the life-like models of our "new Navy made of alloy steel." These sights must have affected the manufacturer or the banker much as the sight of a new mechanized agricultural implement affects the progressive farmer on his visit to the State Fair. Whether or not these thoughts occurred to the engineers who founded the Society for The Promotion of Engineering Education at Chicago in 1893, the teachers of engineers *did* orient themselves from the particular inflection point in human history and they *did* see a need connected with the guidance of engineering education and they *did* start to establish and maintain objectives towards higher levels of unified performance. ALL HONOR TO THEM.

No one can escape the implications of the changes in human affairs which have sprung from the years since 1941. Any World War will beget them, whether they be the influence on juvenile delinquency; the implications of increased alcoholic consumption; the new foreign policy, or the almost casual talk of the expected use of the Pile. We are at an inflection point and it would seem to be as fateful as any we may ever have experienced. What then of possible new tangents or new objectives for us? Certainly they should be only changes of emphasis and not total reorientation or discarding of the old objectives; only re-dedication and here

and there an underscoring of an old principle. In other words, a pause to analyze the trends of the times and to reset our sights.

What are the likely changes or possible shifts in the incredibly complex alignments in human affairs as they may affect us as a Society and our place in the life of the nation?

Is the kind of education in which we are interested on the way to be differentiated between two distinctly different objectives? Will one of these objectives be a tendency toward more and more emphasis on the scientific principles which underlie the practice of engineering, i.e., the three fundamental tools of science with less emphasis on "product engineering"? Along such lines one might visualize three years of mathematics, physics and chemistry for *all* engineers, with only months of specialization and of non-vocational subjects with the understanding that curricula would be built up on a vertical integration through four or five years. One argument for this type of scheme may be found in the statistical fact that a significantly large percentage of graduated engineers do not practice the particular branch of engineering for which they were trained.

The other objective is indicated by a great demand for the technician type of individual who does not need the upper level of the abstract disciplines and actually is incapable of finishing the four or five year curriculum. These students should have a type of technical training between high school and college levels. This problem is already on the way to trial solution in several of the states and it may be vastly more general than heretofore expected.

Both of these questions have been under our active study, an evidence of the timeliness of our work.

The non-vocational aspects of higher education for engineers were mentioned above and the subject is still controversial with many of us in spite of eloquent appeals from our own members in the recent past. Some of our schools are bravely trying the solution of the problems involved, but although one may concede the educational correctness of the humanistic studies for the engineer, there still remains the question of how to carry out the details. Difficulties involving subject matter await solution because of the present pattern of presentation in our sister Arts colleges. Naturally these colleges have tended to develop specialists in sociology, psychology, history and so forth. In a manner, their course sequences have been built in a somewhat analogous pattern to those in engineering, namely, introductory courses and the usual upward trend towards specialization and into the graduate school. Our engineering student will hardly aspire to be a professional historian or teacher of history. Our problem is to work with the teachers of non-technical subjects to devise courses which will meet the following needs: (a) The subject matter must avoid too great an objective towards specialization; (b) The subject matter must avoid mere "fluff" and windy generalizations which certainly will not hold the interest of our students; (c) Broad outlines must be presented which will expand the mental horizon of the technical student and whet his appetite for knowledge of history, or law, or sociology, or biology, or political science, insofar as that broadening will better fit him for the duties of citizenship.

Recently a prominent industrialist

summed up the desirability of the proper blending of the vocational and the non-vocational by saying—"Recognition is given to the importance of many of the subjects commonly included in the curricula of a liberal college. Enough exposure to the main works of history and literature to acquire an interest in further reading and personal study is deemed "essential along with some understanding of accepted laws of economics, the type of thinking economists employ and our system of government and competing systems. Facility in the use of the English language with at least an introduction to a foreign language or two, is also essential." *

Graduate work is becoming more and more a sine qua non for the student of engineering who expects to teach or engage in research. Unfortunately all branches of engineering education have not been sufficiently aware of this fact and here is a challenge to our Society for discussion and recommendations.

Another and entirely different type of responsibility is also clearly ours, and that is the strengthening of what for lack of better words we may call the professional consciousness of the engineer. By this we do not mean the building of pressure groups, or clamorous minorities, but rather intelligent, conscientious, cooperative citizens aware of their professional status and *responsibilities* to society and capable of acting *as engineers* for the common good. This involves esprit de corps, in which we certainly are ahead of some other professions. Let us recognize and cherish this fine status by everything we can do. We can strengthen the morale and the class consciousness of our students by appealing to the *sense of responsibility* of the young engineer. This is no less real in our profession than it is with the medical profession, which has led the way since the time of Hippocrates.

The foregoing problems would seem to be among those which are facing us as a result of the confused ideas and trends in our world of today. The members of our Society have a great opportunity to work with the finest youth in this or any other land; our responsibility is to try to teach them to think properly and effectively because almost certainly the result of their thinking will be given more and more consideration by their fellows as time goes on. This challenge is ours: To better in every way our instruction in science and technology and above all to teach by example and precept that "man does not live by bread alone."

This greeting can best be closed on a note sounded by our beloved Dr. Bishop who the other day in a conversation said something like this—"I am constantly amazed by the strength and solidarity of our Society. It has a spirit of youth and esprit de corps which is wonderful."

* "Basic Sciences and Technology Plus Liberal Courses Produce Well Rounded Engineers." D. H. McLaughlin, *Mining & Metallurgy*, July, 1947, Am. Inst. Min. & Met. Engrs.

Engineering Education for an Atomic Age*

By HUBER O. CROFT

President, American Society for Engineering Education; Professor and Head, Dept. of Mechanical Engineering, State University of Iowa

You and I are unique, for we are of the age trans-Hiroshimo. Most certainly you and I are unique in the sense that we are witnesses at the trial for survival of our own civilization. The records of this trial are not hurriedly registered by the swiftly moving pen, or the impact of a stenotype of the professional court recorder. On the contrary, unfortunately for us the record of this trial is slowly and painstakingly chronicled by that professional group known as historians. The errors we make during our trial cannot be corrected but they definitely will be recorded. So we must do our utmost to prevent error during this trial.

We can approach this entirely new situation which we face in three ways:

First, we can ignore the facts and refuse to imagine the consequences.

Second, we can recognize the facts, continue on our merry way, and remain comfortably complacent doing nothing.

Third, we can recognize the discomforting facts, and as patriotic, educated Americans do our utmost to prevent the historical recording of a lurid catastrophe, at least in our time.

I am sure that most of this group will be numbered under the third and last classification. The question then becomes how can we as educators do our share to preserve the most desirable features of this civilization which our forefathers contrived and we and our fellow citizens now enjoy.

Isn't it strange that we live in a world which has spent billions of dollars to determine accurately the varied equations for nuclear fission and for the design and construction of machinery to promote and control nuclear fission while, at the same time, the amount of money, which we spend to investigate the human equations expressing the delicate relationships between nations, is negligible. If nature's physical laws are stubborn to discover, the laws of human nature, if any, are even more obstinate of revelation. It has taken more than two thousand years and boundless wealth for the periodic table of the chemical elements to be changed from the four pre-Aristotelian elements of earth, water, air and fire to the 92 elements of the pre-Hiroshimo periodic table. If there is time, no doubt at some future date a genius will propose a periodic table for the human elements that constitute national pressures for war and for Peace. Perhaps then, after being given proper directions, humans will wish to become humanitarian. I merely suggest that such a periodic table of human elements should perhaps be worth the expenditure of at least one Oak Ridge.

* Presidential address delivered at the 55th annual meeting, A.S.E.E., Minneapolis, June 17–21, 1947.

Naturally such a table as this would take years to complete but we must do our part now. We as educators simply must exert our influence for preservation of the world in which we find ourselves. This means that we must deliberately plan to train intensively for three-fold possibilities:

(1) Engineering and Science.
(2) National and Civic Service.
(3) International Understanding.

Obviously, we ought to afford to offer the finest, most complete, and most progressive undergraduate courses that can be conceived, but we must do more, for it is essential that we encourage our best young men to undertake graduate work to make certain that our nation will have a sufficient reservoir of research workers, not to compete with, but to surpass any possible world competitor, in discovering and applying scientific facts. Competition is the spice of life to be sure, but being second best in A-bomb competition may mean the end of life for us.

To implement this need undoubtedly, the National Research Foundation bill will be passed by Congress in one form or another. Are you studying your own situation to determine how you and your own institution may assist in carrying out the expressed objectives of this bill and will you encourage a few of your best men to follow the postgraduate path to become skilled research men? I sincerely hope that you will.

But in these days, the training of mere efficient slide-rule engineers is neither in tempo nor in tune with our time. On all sides we see misunderstanding, disagreement and dispute prevailing and, unfortunately, at all levels of human organization whether it be the butcher shop down on the corner, the telephone system which blankets the country, or the tête-à-tête of Mr. Marshall and Mr. Molotov.

While this unrest is natural following the greatest war in history, our students should at least know and recognize the underlying forces at work because our students are to be engineers, yes, but they are also citizens and they should vote intelligently. Furthermore, many of them may find themselves precisely in the middle of an industrial dispute which they may be called upon to arbitrate.

To me, and I hope to you, it is apparent that our students before they graduate must have at least an elementary background for active and intelligent citizenship in our complex republic. In the undergraduate years, introduction of wisely selected courses in the humanities, as has been recommended by committees of our Society, will assist in giving the necessary background. Stimulation to read serious works on the national and international problems of the day will also assist in forming the maturity of judgment we desire for our graduates. To stimulate an undergraduate student to read worthy non-technical books without receiving registrar's academic credit is a challenge to, as well as a test of good engineering teaching. I am one of that group which believes that the undergraduate degree course must be increased to five years of study, which, among other advantages, would give an elementary background for the civic leadership which is expected of engineers. I fully realize that there are those just as firm in their belief that four years of training is sufficient. Time only will prove the solution to the questions at issue.

But specifying a course of study in exact detail for a citizen engineer is not

enough. Sincere and sympathetic encouragment to engage in civil affairs should be presented to the entering freshman engineer, and this should be continued until he graduates. This encouragement should be continued by his employer for only by attending caucases, council meetings, political rallies, and sessions of legislatures and congress does one gain a real and practical understanding of the functioning of our great government. It seems quite clear to me, that the time has come for engineers to stop sneering at politics. The country needs intelligent, trained, honest leaders as never before. It is our patriotic, bounden duty as educators and industrial leaders to heed this urgent demand.

And finally what of the Atom-bomb, which we know how to construct quite well, and of international good will, which we know how to construct, much less well?

It is probably true that we are the wealthiest, the best nourished, the most productive, the most powerful, and outside of our own borders, the most feared nation in the world today. We should also realize that we are the most conservative of all nations holding free elections. It makes little difference if our external moves are stimulated by the inherent idealism of our people—there is always the thought in the minds of citizens of other countries, that underlying our generosity is some sinister, ulterior motive. Discussions with Americans who know and understand foreign countries will substantiate these facts. A thinking man knows that the reactions to fear are irrational and automatic.

The United Nations sensing the need for international understanding has made a start toward this goal. One of the most satisfying experiences of my life has been that as your representative on the First National Advisory Committee of UNESCO, the United Nations Educational, Scientific, and Cultural Organization. This group, authorized by Congress, is one of similar bodies working in most of the member nations of the United Nations to promote Peace, Good Will, and Mutual Understanding between the peoples of the world. What UNESCO lacks in budget is compensated for at least partially by the sincere enthusiasm of its members. All of us hope, I am sure, that UNESCO will succeed in its fundamental objectives.

Now what can we as educators do to alleviate this natural but difficult situation? It seems to me quite obvious that the first step for us to take is to encourage the exchange of more and more students and faculty from outside our borders.

It was through the inspiration of UNESCO that I took the liberty of asking the State Department to send an invitation through each of their consular offices to every country with whom we maintain diplomatic relations. The invitation to attend this meeting in Minneapolis was extended to a prominent engineering educator in each country. The first approach was made to the State Department in December but, for various reasons, the invitations were not sent to the consular offices abroad until April. Dr. Dowdell of the University of Minneapolis was asked to be the liaison official here for all foreign guests. He advises me this morning that 16 guests from foreign shores are among us this morning, and we hope there will be many more before the session closes. It seems to me that invitations to our colleagues abroad, and one session of the annual meeting during which our

guests may talk to us about their hopes and aspirations, and their problems should be an annual tradition. This is one way we as a Society may really contribute to international appreciation and understanding.

May I summarize briefly: First: we must strive to improve our present undergraduate curricula and to prepare our graduates with a knowledge of national and world problems as well as in technical learning. We must induce more carefully selected men to undertake graduate work, not only because it will open greater professional possibilities but also because our country needs them desperately. Second: if we really believe that engineers are intelligent and useful citizens of the state, we should not only contrive curricula that will give them at least a background for a working citizenship, but further we should encourage engineers actively to engage in political service to our nation.

And lastly: the exchange of students and scholars from overseas will contribute much to demonstrate our idealism and good will and furthermore we can demonstrate that at least the rank and file of our citizens do not wish for an A-bomb in their pockets.

General Council, A.S.E.E. 1947-1948

Officers

President

C. E. MacQuigg, The Ohio State University, Columbus 10, Ohio

Vice Presidents

J. B. Robertson, University of Minnesota, Minneapolis, Minnesota (In charge of general and regional activities)

C. J. Freund, University of Detroit, Detroit, Michigan (In charge of instructional divisional activities)

S. S. Steinberg, University of Maryland, College Park, Maryland (Engineering College Administrative Council)

F. M. Dawson, State University of Iowa, Iowa City, Iowa (Engineering College Research Council)

Secretary

F. L. Bishop, University of Pittsburgh, Pittsburgh, Pennsylvania

Treasurer

J. S. Thompson, McGraw-Hill Book Co., New York 18, New York

Assistant Secretary

Nell McKenry, University of Pittsburgh, Pittsburgh, Pennsylvania

Junior Past Presidents

H. O. Croft, University of Iowa, Iowa City, Iowa

H. S. Rogers, Polytechnic Institute of Brooklyn, Brooklyn, New York

R. E. Doherty, Carnegie Institute of Technology, Pittsburgh, Pennsylvania

Divisions

Representatives on Council

Aeronautical—H. W. Barlow, A. & M. College, Texas, College Station, Texas. **2 years.**

Agricultural Engineering—A. W. Turner, Agricultural Research Center, Beltsville, Maryland. **1 year.**

Chemical Engineering—J. H. Koffolt, The Ohio State University, Columbus, Ohio. **2 years.**

Civil Engineering—L. S. LeTellier, The Citadel, Charleston, South Carolina. **1 year.**

Cooperative Engineering—H. K. Justice, University of Cincinnati, Cincinnati, Ohio. **2 years.**

Educational Methods—W. C. White, Northeastern University, Boston, Massachusetts. **1 year.**

Electrical Engineering—C. G. Brennecke, North Carolina State College, Raleigh, N. C. **2 years.**

Engineering Drawing—F. G. Higbee, University of Iowa, Iowa City, Iowa. **1 year.**

English—J. E. Thornton, University of Michigan, Ann Arbor, Michigan. **2 years.**

Graduate Studies—S. C. Lind, University of Minnesota, Minneapolis, Minnesota. **1 year.**

Humanistic-Social—E. S. Burdell, Cooper Union, New York, New York. **2 years.**

Industrial Engineering—P. N. Lehoczky, The Ohio State University, Columbus, Ohio. **1 year.**

Mathematics—J. H. Zant, Oklahoma A. & M. College, Okmulgee, Oklahoma. **2 years.**

Mechanical Engineering—B. E. Short, University of Texas, Austin, Texas. **1 year.**

Mechanics—R. V. James, University of Oklahoma, Norman, Oklahoma. **2 years.**

Mineral Engineering—W. B. Plank, Lafayette College, Easton, Pennsylvania. **1 year.**

Physics—J. G. Potter, A. & M. College of Texas, College Station, Texas. **2 years.**

Technical Institutes—W. L. Hughes, Franklin Technical Institute, Boston, Massachusetts. **1 year.**

Allegheny—D. F. Miner, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. **2 years.**

Illinois-Indiana—W. M. Lansford, University of Illinois, Urbana, Illinois. **1 year.**

Kansas-Nebraska—

Michigan—T. C. Hanson, University of Detroit, Detroit, Michigan. **1 year.**

Middle-Atlantic—

Missouri—

National Capital.—H. H. Armsby, U. S. Dept. of Education, Washington, D. C. **1 year.**

New England—

North Midwest—L. O. Stewart, Iowa State College, Ames, Iowa. **1 year.**

Ohio—O. M. Stone, Case Institute of Technology, Cleveland, Ohio. **2 years.**

Pacific Northwest—Harry McIntyre, University of Washington, Seattle, Washington. **1 year.**

Pacific Southwest—

Rocky Mountain—W. O. Birk, University of Colorado, Boulder, Colorado. **1 year.**

Southeastern—L. J. Lassalle, Louisiana State University, University, Louisiana. **2 years.**

Southwestern—W. R. Woolrich, University of Texas, Austin, Texas. **1 year.**

Upper New York—

Report on Sections

By EARLE B. NORRIS
Vice President

This report must, of necessity, represent merely the ideas of your Vice President, since it is called for before the Committee on Sections and Branches has had opportunity to meet and to prepare recommendations.

Section activities have assumed increasing importance in the value of the Society to its membership. Section meetings serve a far greater percentage of the membership than does the annual meeting of the national organization and they reach to the grassroots of the Society. The Constitution provides that "A section of the Society may be formed by members in two or more institutions within a territory prescribed by the General Council." This sounds as if a section might consist only of members associated with the faculties of the institutions which set up the section. It is my personal feeling that, where the General Council has prescribed the territorial limits of a section, we should consider that all members within those limits should be included in the section membership. This practice could give professional engineers and industrial representatives a greater usefulness to the Society and a greater sense of belonging. Likewise, faculty members of technical institutions (Affiliate Members) would benefit from the opportunity to share in the programs of the section meetings. If this idea is sound it becomes necessary that exact boundaries be fixed for each section. However, I find the practice quite common of visiting back and forth between sections. This is a wholesome practice to be encouraged. Therefore, I suggest that section boundaries should be inclusive, but not exclusive.

There are some institutions and some whole states not within any section as now defined and established. Since the Constitution provides that the initiative for the formation of sections lies in the institutions, the Council is not in a position to dictate, but it may well make suggestions for consideration. The people in the Dakotas are at present without any sectional affiliation. They have no North or South means of rail travel, but all have convenient routes to Minneapolis and thence into Wisconsin and Iowa. It is, therefore, suggested that the North Midwest Section be asked to include in its area all of North Dakota and South Dakota east of the Missouri River. The South Dakota School of Mines is much nearer to and perhaps more closely allied economically with the schools in Wyoming and Colorado. It is, therefore, suggested that the Area of South Dakota west of the Missouri River be assigned to the Rocky Mountain Section.

Utah is another orphan state, with its two state institutions and with two members at Weber College and a few professional engineers in Salt Lake City. In all, there are but 22 members in the state of Utah. Doubtless, some section activity might result in an increased interest. Dean Taylor at the

University thinks that they are officially supposed to be in the Southwest Pacific Section with California, Nevada and Arizona. If so, the officers of that section do not seem to know it and Dean Taylor says rightly that the distances are too great. I suggest a trial of assigning Utah to the Rocky Mountain Section, with the organization of a Utah Section as the alternative.

Arkansas is another orphan state. Dean Stocker tells me that at one time Arkansas and Oklahoma were in a section of their own. The Oklahoma Schools joined with Texas and New Mexico in the Southwestern Section and left Arkansas alone on the outside. They visit nearby sections when convenient, having taken in a meeting of the Missouri Section at Rolla and of the Southeastern Section in Louisville. Since Fayetteville is so near the Missouri border, inclusion with Missouri in a Missouri-Arkansas Section would seem logical. Here, again, I feel that the initiative should come from the schools and not from the Council of the Society. The Kansas-Nebraska Section suggested a change in name to the Missouri Valley Section, but this would be confusing so long as there is also a Missouri Section. There appeared to be some doubt as to the Sectional affiliation of the Michigan College of Mines and Technology at Houghton in the Upper Peninsula. After some correspondence it appears that the sentiment favored inclusion in the Michigan Section and I believe that such reunion took place this spring. In this connection, I would repeat my feeling that we should encourage visiting across sectional borders and that such exchanges of hospitality and courtesy should not require any change of sectional affiliation.

So far as I know there is no attempt at Sectional organization in Canada. It might be well to suggest that the Upper New York Section invite the Toronto, Montreal and Quebec schools to their meetings with the aim either of permanent affiliation or of stimulating the creation of an Ontario-Quebec Section.

The Maritime Provinces might also form a section of their own.

British Columbia might readily be included in our Pacific Northwest Section.

That leaves the Universities of Manitoba, Alberta and Saskatchewan spread out over a distance of 827 miles by rail, and with but one member in each school. That distance is, however, no greater than the extent of some of the sections in the United States if we could stimulate more interest and an increased membership.

Branches

During the year the Purdue Branch has surrendered its status as such by reason of the fact that the Illinois-Indiana Section and the Engineering Faculty meetings at Purdue seem to cover the problems originally intended to be considered by the Branch.

In Minnesota we had a Section listed although its membership was from the University. This section has asked that it become a Branch and that Minnesota be included in the North-Midwest Section.

Believing that the spirit of our Sectional organization, as well as the letter of our Constitution places the initiative for sectional organization with the institutions concerned, I am making no recommendations to the Council other than that my successor might communicate my suggestions to the schools and sections concerned for their consideration and possible action.

Report of the Secretary, F. L. Bishop, for 1946-47

The Constitution of the American Society for Engineering Education provides for three Councils, namely, the General Council, the Engineering College Administrative Council, and the Engineering College Research Council. This is a report to the General Council. This Council is composed of officers of the Society and representatives from every division and section. These representatives serve for a period of two years under the plan of rotation in which one-half of each group will be chosen each year.

In general, the new Constitution of the Society has proved satisfactory although there are minor changes which should be carefully considered by the Committee on the Revision of the Constitution.

The Constitution assigns to this Council specifically the problems pertaining to teaching. The greatly increased attendance in engineering colleges and the large number of new and inexperienced teachers in the colleges have increased very materially all old problems of instruction and created many new ones. It is the duty of this Council to assist on the solution of these problems.

Membership. The present members of the Society is 4,820 of which 165 are institutional members. There have been elected 887 new members through the efforts of the Membership Committee under the chairmanship of President Croft. This Committee was composed of one member from each state who selected aides from the different colleges. This is the largest number of new members to be elected in a single year. The distribution of new members is interesting. There are approximately:

	Total membership per cent	per cent
Instructors	30	10
Assistant professors	21	15
Associate professors	12	16
Professors	12	32
Presidents and deans	13	11
Industry	10	14
Miscellaneous	2	2

We have lost 17 by death, T. R. Agg, W. N. Barnard, E. S. Gray, M. E. Holmes, S. S. Garrett, G. A. Mancy, P. C. Nash, J. T. L. McNew, R. G. Paustian, T. T. Read, A. J. Tremblay, D. M. Russell, Albert Siepert, H. W. Waterfall, C. C. Williams, F. C. Stockwell; 252 by resignation.

With the greatly increased faculties required in the engineering colleges it seems as though we might look forward to a large increase in membership next year.

The various sections, divisions and committees have been doing notable work throughout the year. Some of these results are indicated by the program of the conferences. One of the notable contributions is the summer school for mechanical engineers held at Northwestern University just prior to this meeting.

Section meetings were curtailed during the period of the war. These meetings have in most cases been resumed. The attendance and interest have been exceptional. The papers presented were excellent and some have been printed in the JOURNAL. We shall

hear more detailed reports from the section representatives.

President Croft has been very generous in giving his time to attend the sectional meetings. This is an important duty of the President.

President Croft will make a report to you in regard to the various ballots which he has taken during the year.

Publications. The shortage of paper and labor troubles made it rather difficult to issue the JOURNAL and in almost every case it was delayed for these reasons. The cost of the JOURNAL has greatly increased over a period of years and especially during the past year.

Enrollment figures were obtained in the usual way by this office but several institutions failed to make returns, among them were some of the larger institutions. Dean H. P. Hammond has been making a study of enrollments for other purposes and found that statistics given us were not the same as those given to him. You will be interested in the following figures which he gives:

"The JOURNAL's tabulation is based on 130 American schools, which omits about 25 schools, including such large ones as Illinois, Missouri, CCNY, Lehigh, George Washington, and Oklahoma A. & M. I have estimated the 1946–47 enrollments of these schools by taking their own predictions of enrollments for 1947–48 and reducing these by the average increase we have found between 1946–47 and 1947–48 from reports from over one hundred institutions. While the result is subject to error, caused by this method of estimation, nevertheless it does give a rough approximation of the total number of students. My estimates indicate that the total enrollment of undergraduates in schools in the United States for 1946–47 was about 222,000 and, including graduates, about 236,000." (Our figures were 197,797 undergraduates.)

Report of the Treasurer for 1946–47, J. S. Thompson

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF CASH ACCOUNT
June 12, 1947

	1945–46 (June 12, 1946)	1946–47 (June 12, 1947)
BALANCE ON HAND:		
Forbes National Bank—Checking Account	$13,227.07	$16,115.93
Forbes National Bank—Savings Account	639.25	—
	$13,866.32	$16,115.93
RECEIPTS:		
Current Dues	$17,346.41	$23,519.23
Back Dues	1,560.00	2,022.50
Dues in Advance	517.50	675.50
Sales of Publications	1,002.17	1,071.04
Advertising	4,304.02	5,032.76
Sale of Emblems	12.25	1.25
Interest on Savings Account	3.20	—
Interest on Government Bonds	258.75	351.25
Refund—Humanistic-Social Studies	164.40	—
Refund—to Close Summer Session Account	104.77	—
Receipts from Dinners	371.00	—
Refund on Gold Emblems	—	91.43
Westinghouse Educational Foundation	—	250.00
General Education Board Southeast Sec.	—	10,000.00
Carnegie Corp. ECAC Survey on Eng. Salaries	—	6,000.00
Total Receipts	$25,644.47	$49,014.96
DISBURSEMENTS:		
Cost of Publications	$10,474.28	$13,201.33
Honorarium for Secretary	2,000.00	2,200.00
Clerical Assistance	4,172.25	4,500.00
Travel and Entertainment, Secretary's Office	407.62	286.96
Printing, Postage, Office Supplies, etc.	986.20	2,063.93
Purchase of Equipment	648.78	—
Dues—American Council on Education	100.00	100.00
Contribution to Engineers' Council for Professional Development	750.00	650.00
Officers' Traveling Expenses	477.83	663.51
Expenses—1945 Meeting	153.85	—
Expenses—1946 Meeting	410.22	600.61
Expenses—1947 Meeting	—	1,166.25
Expenses—ECAC	520.17	828.22
Expenses—Revision of Constitution	390.89	—
Expenses—Committees and Conferences	711.15	670.82
Council Meeting	335.35	—
Purchase Series G Government Bonds	700.00	5,000.00
Expenses—Westinghouse Award	—	357.10
Emergency Expense	—	735.00
Va. Poly. Inst. for Manual	—	200.00
Total Disbursements	$23,394.86	$33,523.61

BALANCE ON HAND:		
Forbes National Bank—Checking Account	$16,115.93	$31,607.28
Total Balance on Hand	$16,115.93	$31,607.28

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF INCOME AND EXPENSE
For the Years Ending June 30, 1946 and 1947

	1945–46 (June 12, 1946)	1946–47 (June 12, 1947)
Income:		
Current Dues	$18,581.41	$25,036.73
Back Dues	560.00	1,022.50
Sale of Publications	1,002.17	1,071.04
Advertising	4,404.02	5,332.76
Sales of Emblems	12.25	1.25
Refund on Gold Emblems	—	91.43
Interest on Savings Account	3.20	—
Interest on Government Bonds	258.75	326.25
Refund to Close Summer School Account	104.77	—
Receipts for Dinners	371.00	—
Total Income	$25,297.57	$32,881.96
Expense:		
Cost of Publications	$10,274.28	$13,832.71
Expenses—1945 Meeting in 1946	213.02	1,010.83
Honorarium for Secretary	2,000.00	2,200.00
Clerical Assistance	4,172.25	4,500.00
Printing, Postage, Office Supplies, etc.	986.20	2,063.93
Travel and Entertainment—Secretary's Office	407.62	286.96
Dues—American Council on Education	100.00	100.00
Contribution to Engineers' Council for Professional Development	750.00	650.00
Officers' Traveling Expenses	477.83	663.51
Expenses—ECAC	520.17	828.22
Expenses—Civil Engineering Division	156.27	299.88
Expenses—Conference on Social Humanities Problems	295.60	—
Expenses—Revision of Constitution	390.89	—
Expenses—Committees and Conferences	711.15	670.82
Council Meeting	335.35	—
Emergency Expense	—	735.00
Va. Poly. Inst. for Manual	—	200.00
Total Expense	$21,790.63	$28,041.86
Surplus for the Year	3,506.94	4,840.10
Total	$25,297.57	$32,881.96

American Society for Engineering Education
Comparative Balance Sheet
As of June 30, 1946 and 1947

Assets

	1946 (June 12, 1946)	1947 (June 12, 1947)
Cash:		
Current Fund	$16,115.93	$31,582.28
Petty Cash Fund	300.00	300.00
Life Membership Fund	1,045.92	78.40
Total Cash	$17,461.85	$31,960.68
United States Government Series G Bonds		
Current Account	$10,700.00	$15,700.00
Life Membership Fund	—	1,000.00
Total Bonds	$10,700.00	$16,700.00
B. J. Lamme Trust Fund:		
Securities and Mortgages	$ 5,108.41	$ 5,093.25
Uninvested Cash	35.84	51.00
Checking Account	178.54	204.45
Total Lamme Fund	$ 5,322.79	$ 5,348.70
Prepaid Expenses:		
1946 Meeting (1947)	$ 410.22	$ 1,166.25
Inventory (Nominal)	1.00	1.00
Accounts Receivable:		
Advertising	1,200.00	1,500.00
Dues	1,000.00	1,000.00
Westinghouse Educational Foundation	—	107.10
B. J. Lamme Award	191.49	—
Furniture and Fixtures (Nominal)	748.78	748.78
Total Assets	$37,036.13	$58,532.51

Liabilities

Life Membership Fund	$ 1,045.92	$ 1,078.40
B. J. Lamme Trust Fund	5,322.79	5,348.70
Prepaid Membership Dues	517.50	675.50
General Education Board for Southeast Section	—	10,000.00
Carnegie Corporation for ECAC	—	6,000.00
Total Liabilities	$ 8,886.21	$25,733.98

Surplus Account

Balance	$24,642.98	$28,149.92
Less—Cancellation Account Receivable Lamme Award	—	191.49
Revised Balance	$24,642.98	$27,958.43
Surplus for Year	3,506.94	4,840.10
Total Liabilities and Surplus	$37,036.13	$58,532.51

1947
(June 12, 1947)

$31,582.28
300.00
78.40

$31,960.68

$15,700.00
1,000.00

$16,700.00

$ 5,093.25
51.00
204.45

$ 5,348.70

$ 1,166.25
1.00

1,500.00
1,000.00
107.10
—
748.78

$58,532.51

$ 1,078.40
5,348.70
675.50
10,000.00
6,000.00

$25,733.98

$28,149.92
191.49

$27,958.43
4,840.10

$58,532.51

Report on the Engineering College Administrative Council

During the past year the Administrative Council sought to establish a pattern for the operation of this division of the Society. Its executive committee, which met in the fall in Washington, in December in Chicago, and in June in Minneapolis, approved and started the following projects:

(1) The publication of a bulletin, which was handled by Dean W. C. White, the Secretary of the Administrative Council. The object of this bulletin has been to present topics of general interest to administrators of American engineering colleges and to serve as a medium of exchange among officers of these institutions.

(2) The completion, discussion, and distribution of a report on Academic Tenure, Professional Service and Responsibility prepared by a committee under the chairmanship of C. J. Freund. Responses from college officers commenting on this report bear testimony to its influence.

(3) A study of the problem of faculty salaries in engineering colleges. The executive committee enlisted the assistance of Dr. Dugald C. Jackson to undertake this study, and he presents a first report at the second general session of this convention. A notably high return on the information requested was obtained from the colleges, and the report therefore represents the most complete available information on this subject.

To extend this study and to obtain relative data on other types of organizations employing professional people, the executive committee sought extra funds, and as a result of a proposal to the Carnegie Corporation of New York the Administrative Council has received a grant of $6,000 for this purpose. During the coming year, therefore, the study of salaries will be continued under Dr. Jackson's direction, and information will be sought from other professional schools and from industry.

(4) A study of the problems involved in the transfer of students from emergency institutions to engineering colleges. Dean Harry P. Hammond undertook the chairmanship of a committee to study this problem, and this group carried through a remarkably detailed survey of present problems in enrollment. A notable report of its findings was presented at the second general session of the Minneapolis convention.

(5) A study of the problem of ROTC programs in engineering colleges. This resulted in a full session on this subject as a part of the program of the Minneapolis meeting.

During the year, the Administrative Council's Committee on Military Training Programs, under Dean Thorndike Saville, was very active and collaborated with the Engineering College Research Council in the study in Washington of Federal legislation affecting engineering colleges.

Representatives of the Administrative Council were afforded an opportunity by the Army to inspect the Universal Military Training Experimental Unit at Fort Knox.

The Administrative Council operated on a budget of $1,850 for the past year, and it now appears that this amount substantially represents its expenditures.

The President of the Administrative Council expresses his appreciation for the effective work of the executive committee of the Council and of the various subcommittees which were appointed. They formulated and carried through a program for the Council which I think it is fair to say continues it as an effective instrument for the assistance of our engineering college administrators. The chairman wishes especially to express his appreciation to Dean W. C. White, who carried out the work of Secretary with great efficiency and at all times kept the President alerted to what should be done and how it should be done.

Respectfully submitted,

J. R. KILLIAN, JR.,
President

Report of the President of the Engineering College Research Council

This 1947 Annual Meeting marks the end of the first year of formal affiliation between the Engineering College Research Council and The American Society for Engineering Education. At the annual meeting of the Engineering College Research Association one year ago in St. Louis, the Secretary of the Association announced the approval by our membership of a general proposal to merge the Research Association into the reorganization of the Society for the Promotion of Engineering Education, as the Engineering College Research Council of the American Society for Engineering Education.

At that time a Committee was appointed to formalize the terms of this affiliation; the report of this Committee, in the form of By-Laws for the Engineering College Research Council, was accepted late last year by our membership and became effective on January 1. Every effort was made to carry out the commission of the members of the Engineering College Research Association expressed at the 1946 Annual Meeting. Thus the E.C.R.C. is able to carry on autonomously in its public relationships and its publications program. We have an effective union with the A.S.E.E.: the President of the Research Council is a member of the Executive Board of the A.S.E.E. we report to the President of the Society, and our financial arrangements are coordinated with those of the Society by the Society's Treasurer. After one year's experience, we feel certain that the original objectives of the Research Association will not be submerged but very considerably brightened by the affiliation activated during the year. I firmly believe that, while the full promise of our new relationship with the A.S.E.E. has not yet been realized, the first year has given strong evidence that this new relationship can be of great benefit to both organizations.

To support this conclusion and to make a proper report to the members of the A.S.E.E., I want to review briefly the activities with which the Research Council has been occupied during the past twelve months. Our work has centered around our three principle committees; in addition, and in conjunction with the work of these committees, we have carried on an active and independent publications program.

Our Committee on Relations with Federal Research Agencies is authorized to act in an advisory capacity to any government agency in furthering cooperative research between that agency and any members of the Research Council. It is also authorized to undertake to advise a federal research agency as to institutions which are adequately equipped to perform research of a stated character. Through this committee in past years we have

made valuable contacts with the directors of a number of government-sponsored research programs. These contacts have been furthered this year. In addition, the Committee has assisted several branches of the Armed Services in obtaining detailed information from our member institutions about research facilities and interests in certain specialized fields. By invitation, several representatives of our member institutions had the unusual opportunity of visiting the Army Ground Forces Winter Test Task Forces in Wisconsin and Alaska, and their reports have been circulated to our membership. It is evident that the attitude of the engineering colleges toward research and research training has been neither completely understood nor accepted by some of those directing government research programs. It is equally clear that difficulties and misunderstandings exist in matters of technical contractual relations between colleges and government agencies. The future work of our Committee on Relations with Federal Research Agencies in both these fields should be helpful.

Establishment of the National Science Foundation, if it is approved by Congress, will bring additional problems of government liaison, which I believe the Research Council will be well prepared to accept.

As a result of changing emphasis from war-time to peace-time engineering research, a Committee on Relations with Industrial Research Groups was activated by the Research Council following the annual meeting last year, and in its first year of service this Committee has already discovered many opportunities for important service. After reaching some conclusions as to the policies and attitudes of the engineering colleges toward research sponsored by private industries, the Committee sponsored a most successful roundtable Tuesday evening of this week on the subject of "The Relation of College Research Organization to Industry." The Committee is now considering plans to help bring an understanding of college research policies and attitudes to the attention of industrial groups. At the same time the Committee will return to us with information about the desires and requirements of industry. I believe that this program for mutual understanding can go far to extend the value and scope of the research investigation and training which engineering colleges perform for industry.

As most of you know, for several years the Engineering College Research Association was active in support of the interests of the engineering profession in the proposed National Science Foundation. One of the first fruits of the affiliation between the Society and the Research Council came early this year with the appointment of a Joint Committee on Federal Legislation, in conjunction with the Administrative Council. Dean Saville will follow on this program with a brief report on the National Science Foundation bill, thus far our major legislative interest. Later Dean Norris will speak of another bill now before the Senate. The membership of the Research Council has been kept in touch with developments on these matters by a large number of circular letters from the Secretary's office. I believe we have made a substantial contribution to the success of the National Science Foundation bills, and I am certain that the groundwork has been laid for more complete representation of the interests of engineering education in legislative matters.

To supplement the activities of the various committees, the Research Council throughout this year has carried on an active publications program. Early in the fall the papers from the last annual meeting of the Association were assembled and published as Proceedings, and these have had circulation among industrial firms and the technical press as well as our member organizations. During the winter there was published a mimeographed book entitled "Exhibit of Patent Policies in 22 Colleges and Universities," which actually contained statements of patent policies from 24 member institutions. The Executive Committee has just authorized the reprinting and further distribution of this publication, and we hope to make copies available to all institutional members of the Society who may be interested.

At its annual business meeting last Wednesday, the Research Council announced publication of a new "Directory of Member Institutions and Review of Current Research." This publication, which has constituted the major project of the Secretary's office since March, undertakes to give a brief summary of research and contract policies at each member institution and indicates the fields in which each is particularly active in research, normally by giving a list of current research projects. We have distributed a number of copies at the meetings so far, and some have undoubtedly seen the new book. I might add that it has been accorded a very warm welcome, for which we are most gratified. Yesterday morning the Executive Board of the Society authorized its reprinting for distribution to all the industrial research laboratories listed in the National Research Council Bluebook. While we are anxious to prevent waste of the present edition, there are copies on the table here for general distribution to research officers and others who may be interested at the close of this session.

The end of the war has resulted in decreased high-pressuring of engineering research and increasing interest in fundamental research problems. We all suspect that this is a most healthy influence. Despite the pressure of greater teaching loads, the year has brought in general a most favorable climate for research activities in engineering colleges. I see no reason to fear that this favorable climate cannot continue. The nation is conscious of the importance of scientific research as never before, and particularly in the field of basic research much psychological and some financial support is happily available. In this respect, the possibility of a National Science Foundation cannot be underestimated.

This is not to say that serious problems do not remain for engineering colleges active in research. Many of our members are relatively new in the business of directing and supervising engineering research; some are doing engineering research on a peace-time basis almost for the first time. We hope soon to bring into more active association with the Research Council many institutional members of the Society whose research activities do not qualify them for full membership in the Research Council. All of these groups are actively seeking solutions to a number of mutual problems, by mutually comparing experiences and results. The wide interest during the week just ending in the sessions of the Research Council, and other Society sessions dealing with research, is evidence of our present curiosity. The potential role of the Research Council is obvious.

The Constitution of the A.S.E.E. lists four primary purposes of the Council: (1) To further advanced study and research (both fundamental and applied) in engineering colleges; (2) To undertake sponsorship of such research to promote advancement of education and the profession; (3) To represent its members in cooperative work with associations and government agencies; and (4) To publish periodic reports of value to engineering research. I am very happy to report that, on the basis of our first year's activities, I believe our affiliation with the A.S.E.E. gives promise that these purposes can and will be achieved in full measure. I am certain that our activities this year represented substantial progress toward our goal. I look forward to the years ahead with confidence that the Research Council will further prove its importance to the cause of engineering research and to the broad profession of engineering.

Report of Committee on Transfer of Students from Emergency Institutions*

In the fall of 1945 approximately 73,000 students were enrolled in the engineering colleges of the United States.† In the fall of 1946 enrollments had increased to more than 225,000. At that time fifteen institutions enrolled more students than had all the engineering schools of the country the year before. The Compton Committee report of 1946 refers to a recent survey which stated the estimated capacity of the engineering schools of the United States to be 155,000 students. Thus in a single year engineering enrollments had more than trebled and now exceed estimated maximum capacity by nearly fifty per cent. Data gathered by the Committee which submits the present report indicate that engineering schools of the United States are expecting to admit approximately 85,000 new students—freshmen, upperclassmen, and postgraduates—during the academic year 1947–48, and that their total enrollments of all students, new and old, may be approximately 250,000. Because of the growth of interest in scientific and technical pursuits one student out of every nine students of the country, including both men and women, is now enrolled in engineering (not including related fields of physical science), and no abatement of this trend is in immediate prospect. Thus it seems clear that a rapid rate of increase of enrollments will continue during the coming year and that the resources of engineering schools, already seriously overtaxed, will be loaded still further.

In spite of most strenuous efforts by all concerned to provide to the greatest possible degree to meet these demands, a great many students who desire to study engineering have been unable to gain admission to regular engineering colleges and have been forced to enter a variety of other types of institutions. Most of these students will seek admission to engineering colleges later. At the same time young men still in military service, including both those who have and those who have not previously attended college, will seek admission upon their return. Unless some form of military training law is enacted which will call students directly from high school to training camps, another wave of students just graduated from high school will add itself to the waves of applicants and students now in college.

The total situation that confronts engineering colleges is, therefore, indeed a complex and difficult one, the most difficult, perhaps, of that of any important group of institutions. One phase of this general situation is that which relates to the admission of students by transfer from the several types of insti-

* Presented at the 55th Annual Meeting, A.S.E.E. (Administrative Council), University of Minnesota, June 17–21, 1947.

† In 1941–42, the last year of normal "prewar" enrollments, the total number of engineering students in the United States was approximately 115,000.

tutions in which they are now enrolled for their earlier years. The Executive Committee of the Engineering College Administrative Council requested our Committee to review this situation, to appraise the magnitude and nature of the problems involved, and to recommend policies and practices in relation to them. This we do in the report that follows.

Early in our Committee's discussion two points became clear:

1. It was not desirable to confine attention to special new colleges established during the present emergency chiefly to accommodate veterans. Problems incident to the transfer of students from such institutions to engineering schools seemed not to differ essentially from those incident to transfer from regularly established colleges that do not customarily admit pre-engineers, nor from those arising from the transfer from all types of "feeder" institutions that have now greatly expanded their enrollment. We have therefore included in our considerations students now enrolled in the following types of institutions:

(*a*) Off-campus branches of the parent institution.

(*b*) Institutions to which students, enrolled in the parent institution, have been "farmed out" for their first year or, perhaps, first two years.

(*c*) Colleges of various types—liberal arts, teachers' colleges, women's colleges, etc.—many of which do not customarily admit pre-engineers.

(*d*) Junior colleges which may or may not previously have admitted pre-engineers.

(*e*) "Emergency colleges" established with the specific purpose of providing, temporarily, educational opportunities for those unable to gain admission elsewhere.

2. It appeared to be impracticable accurately to determine the total number of students in the entire country who may seek to gain admission by transfer to engineering colleges this fall. We are able to present some territorial samples and to hazard an estimate of total demand, and we have gained a reasonably clear conception of the more important aspects of the conditions—such as the extent of freshman-year preparation—that surround the admission and adjustment of transfer students to engineering college programs.

In particular, it has become abundantly clear that the capacity of engineering colleges to admit all applicants will be far short of the demand no matter what expedients might be adopted to provide for them.

Magnitude of the Problem

We present first a comparative summary of enrollment statistics for 1946–47 and estimated total capacities to receive students in 1947–48, based on responses from 108 engineering colleges in all parts of the country. The same institutions are included in the two sets of figures. Estimated capacities to admit new students are given in columns (7), (8), (9), and (11). Figures in column (2) should not be compared with those in column (7), since the latter do not include any freshmen carried over from last year, as in institutions that admit students at mid-years. Prospective percentage increases in total enrollment of undergraduates and postgraduates and of all students are given in columns (10), (12), and (13).

TABLE I

1946–47

1	2	3	4	5	6
No. of Colleges	Freshmen	Soph. Jr. Sr.	Total Undergr's.	Post-gr's.	Total Stud's.
108	72,110	91,522	163,632	12,705	176,337

1947–48

7	8	9	10	11	12	13
New Freshmen	New Soph. Jr. Sr.	Total New Undergr's.	Total Undergr's.	New Postgr's.	Total Postgr's.	Total Stud's.
47,437	13,306	60,743	183,809	5,160	13,726	197,535
Increase, 1946–47 to 1947–48			12.3%		7.5%	12.0%

By extrapolation based on the ratio of total students from 1946–47 in the above tabulation to the total of those tabulated in the JOURNAL OF ENGINEERING EDUCATION for January 1947,* a rough estimate of total enrollment for 1947–48 would be as follows:

TABLE II

Undergraduates	236,500
Postgraduates	16,000
Total, Undergraduates and Postgraduates	252,500

By similar extrapolation, the number of new students to be admitted in 1947–48 is estimated roughly to be:

TABLE III

New Freshmen	61,000
New Sophomores, Junior, and Seniors	17,200
New Postgraduates	6,000
Total New Students	84,200

* These statistics have been adjusted for apparent duplication of veteran enrollments in some institutions and for omission of statistics from other institutions.

These latter figures may be taken as the approximate capacity of the engineering colleges, with existing facilities, to admit new students during 1947–48. They may be compared with the total increase of 137,000 students (210,000–73,000) between the fall of 1945 and the fall of 1946. This will give some concrete conception—though an incomplete one—of the extent to which prospective engineering students who seek admission are being dammed back.

Students Seeking Admission. Sampling surveys of colleges of liberal arts, junior colleges, and one emergency college, in California, Pennsylvania, and eleven mid-western states, enrolling in all 160,279 students, indicated that 15,495 of these students desire to transfer to engineering colleges, a ratio of 9.7 per cent.* If this ratio holds for the

* This ratio varies widely in different types of institutions and, apparently to some extent, in different sections of the country. Our Committee's studies show a range from 3.9 per cent in liberal arts colleges in Ohio to 12.8 per cent in junior colleges in California.

total national enrollment of approximately 930,000 students † in similar institutions, the total number seeking admission to engineering in advanced standing is approximately 90,000. (This figure is perhaps unduly weighted by enrollments in California Junior Colleges.) This society's Committee on Manpower estimates this number to be approximately 55,000 freshmen and 22,000 members of other classes, mostly sophomores. These students will doubtless not all desire to transfer in one year. However, the comparison of the total number comprising this group with 17,200, the number of new sophomores, juniors, and seniors which our Committee estimates the engineering colleges can receive next year, is significant of the general situation surrounding engineering education to which reference has already been made. Most institutions will give priority to their own returning ex-servicemen in filling these 17,200 vacancies. It seems unlikely that a large fraction of the 80,000 or more students now enrolled in other types of institutions awaiting transfer will gain admission to engineering colleges either this year or next year.

The Nature of the Problem

Part of the problem that will confront engineering colleges this fall arises from the number and variety of types of institutions in which transferring students have been enrolled. However, they seem not to promise any more or as much difficulty either in the nature of the problems or in number of students affected as have those incident to the re-adjustment of former students of the Army Specialized Training Program with which we have become familiar in the past year.

The principal types of institutions in which students awaiting transfer have been enrolled have already been named. Remarks about each type, condensed from a considerable volume of material, may be of some interest and value.

State Sponsored Emergency Colleges. The state education departments of Massachusetts, New York, Pennsylvania, and North Carolina have sponsored and supported the organization of special emergency, and presumably temporary, institutions as follows:

Fort Devens College, Massachusetts.
Champlain, Mohawk, and Sampson Colleges, New York.
The so-called "Area College Centers," ten in number in Pennsylvania under the direct supervision of the State Department of Public Instruction, and seven additional area or "Credit" centers administered by The Pennsylvania State College in cooperation with the State Department of Public Instruction.
Twelve centers of instruction in North Carolina.
Farragut College in Idaho, which is also of emergency type but is privately financed.

In Massachusetts, New York, and Idaho the institutions are located on military reservations. In Pennsylvania and North Carolina classes are conducted during the late afternoon or evening hours in high school buildings. Boards of trustees of the institutions are for the most part comprised of presidents of institutions of the state or vicinity. Equipment for science courses, meager at the start, is now being accumulated more adequately. In some states, faculties are comprised of experi-

† See "Study of Pre-Engineering Enrollment in Colleges and Universities (as of November, 1946)," by Henry H. Armsby, U. S. Office of Education.

enced college teachers; in others, high school teachers are employed. In Pennsylvania the proportion of college teachers in the various area colleges ranges from 100 per cent to zero. All teachers appear to be carefully chosen, drilled, and supervised and their morale and effectiveness have been commented on favorably by members of the Committee who visited the institutions and observed their work. Admission requirements are much the same as in many publicly supported institutions though rather more liberal, both in statement and in application. Requirements in mathematics are somewhat light, but with few exceptions, entering students offer more than minimum requirements. Curriculum requirements are about the same as in regular engineering schools, except for fewer total required credits, the following examples being typical:

Freshman year, each semester:

Mathematics—semester credit hours	5
Chemistry	4½
Drawing and descriptive geometry	4
English	3
Total	16½

Freshman and sophomore years, total credits for four semesters:

Mathematics—semester credit hours	16
Chemistry	10
Physics	8
Drawing and descriptive geometry	6
English	8
Total	48

In New York and Pennsylvania more than one-third of the students in emergency colleges were enrolled in engineering.

While most of these institutions were for the most part originally established to offer work of the freshman year only, the pressures upon them are such that steps are being initiated to extend their programs to two years, and at least one institution has announced the hope of becoming permanent. If students continue in them for more than two semesters the problems of senior engineering schools to provide programs such that they can complete normal degree requirements in a total of eight semesters are likely to be very difficult. Summer session adjustment programs may be necessary for such students.

Liberal Arts, Teachers', Women's, and other Types of Colleges. These institutions in the aggregate enroll a good many students hoping to transfer to engineering. It is from these instituions, many of which have little or no prior experience with pre-engineers, that perhaps the greatest variety of problems will arise. The institutions vary within wide limits of quality, up to the highest ranks of academic excellence—as with certain of the women's colleges. Standards of admission also vary: in some instances where the admission of male veterans has been undertaken as a public service, admission standards have been relaxed as compared with those required of regular entrants. Curricula also vary widely, from those substantially the same as the usual engineering freshman year to some that differ in important respects. The following, for example, omits engineering drawing:

English—semester credits	6
Bible	3
History, economics, or other elective	3
Chemistry	6
Mathematics	6

Another example of admission requirements and pre-engineering curriculum provisions in twenty-four lib-

eral arts colleges in Kentucky, Indiana, Michigan, and Ohio follows:

Typical entrance requirements, in Carnegie units:

English	3
Foreign language	2
History	1
Laboratory science	1
Mathematics	2
Total specified	9
Total required	15

Curriculum provisions, freshman and sophomore years, in semester credit hours:

	Most Frequent	Min.	Max.
Chemistry	8	8	16
Physics	10	8	16
Mathematics	19	15⅔	28
Drawing	3	0	6
Descriptive geometry	3	0	5
English	6	0	12

Some of these curricula exemplify a particular point: semester credits in mathematics, in some instances, are limited to six for the freshman year. Yet an examination of the syllabi of the courses discloses that the work extends through analytical geometry, and acquaintance with the quality of the work of the institutions and a study of examination papers make it clear that students who pass the courses will have covered fully the work of the customary engineering requirements in trigonometry, college algebra, and analytical geometry. Male students taking certain of the courses were finding difficulty in keeping up with the women students. The point to be observed appears to be that evaluation based on credits awarded in the feeder institutions may be misleading, either one way or the other: over-evaluation or under-evaluation. Placement tests in mathematics and science may be a more accurate way to appraise the preparation of students transferring from this group of institutions.

Junior Colleges. The situation as to transfer from junior colleges differs from previous experience chiefly as to the numbers of students involved and the fact that some engineering colleges are likely to admit such students in significant numbers for the first time. In this connection it may be appropriate to remark that the present emergency is tending to accelerate the trend toward enrollment of students in the thirteenth and fourteenth (junior college) grades of public school systems and thus greatly, and perhaps permanently, to increase the number of students seeking admission to the junior year of engineering colleges.

Off-Campus Branches of the Parent Institution. No phase of the present emergency is more interesting than the establishment of branches of the main institution. As examples, Illinois has branches at the Navy Pier, Chicago, enrolling 2,500 freshmen, a branch at Galesburg, enrolling 1,000 freshmen, and "Centers" in more than thirty high schools. The numbers of pre-engineers at these branches in 1946–47 were, respectively: 1,300, 100, and 1,000 (650 of whom are headed for the University's campus). Wisconsin has thirty-four extension centers enrolling 5,500 students, including pre-engineers. Iowa State College and Georgia School of Technology have overflow groups at nearby military camps and transport faculty or students or both back and forth from campus to camp for special purposes, such as instruction by teachers or laboratory work by students. Other uni-

versities have also established branches, but the details of their operation are not known to our Committee. The Pennsylvania State College has "farmed out" its first-year students as follows: to its own four "undergraduate centers," or junior colleges, to its school of forestry, to thirteen state teachers colleges, and to four cooperating privately endowed colleges, where its 3,000 freshmen, including 1,000 engineers, are enrolled. In these instances the regular freshman engineering curricula are in effect, and the work is coordinated by the parent institution. Curricular problems of transfer will not be difficult. Placement examinations in English and mathematics are proposed as means of determining whether special adjustments will be needed in subject matter or to upgrade students.

A similar process of farming out students has been adopted by Alabama Polytechnic Institute and the University of Alabama which have 1,000 students enrolled in "basic curricula" of the freshman and sophomore years in twelve cooperating institutions. There is no guarantee of admission to the parent institution at the end of the two-year period.

Summary

The most significant condition that confronts the colleges of engineering is the sheer weight of numbers. The necessity of providing special adjustment programs for students transferring in advanced standing tends to augment difficulties caused by overcrowded enrollments by imposing additional scheduling and adjustment problems on heavily burdened teaching and administrative staffs. More than the normal number of hours of the academic day, the teaching of abnormally large classes and the accompanying load of problem correction, working under the strain of attempting to maintain proper standards of instruction, often under very difficult conditions—all of these add to the difficulties of operating engineering colleges. In short, conditions are without precedent.

In most instances the campus work of engineering schools is being done in very little space in addition to that available in pre-war years. In a majority of institutions it has not been possible to increase faculties in proportion to the increase in students. Budgets have lagged far behind enrollments. And over everything hangs the uneasiness that results from not being able to provide for the tens of thousands of worthy applicants who cannot be admitted.

Of course, there are brighter sides of the picture. Chief of these is the high quality of our students and the purposefulness of their work. Never before have we had such an able, courteous, or responsive group of students to work with; and that serves greatly to ease all our difficulties. Another is the boon of increased research activities; which also helps to maintain our morale. Finally, there is the stimulus which comes from the increase in graduate work. Somehow, in spite of the compounding of burdens, we are managing, collectively, to progress in both these latter directions. And this is vital to the welfare and progress of engineering education.

Our Committee has discussed these matters with a view to selecting those aspects of the problems on which recommendations may be laid before you.

We recommend as follows:

1. That while colleges should operate as nearly as possible at full capacity, they should not admit more stu-

dents than can be taught effectively. On the average, it seems probable that the maximum number that can be admitted under this condition will be reached in 1947–48.

We base this recommendation on the fundamental belief that the one fault that should be avoided at all costs is the providing of substandard education, especially for students preparing for professional careers.

2. That facilities and staffs be devoted to as great an extent as feasible to upperclassmen and graduate students. Since there is a large surplus of applicants for admission in advanced standing, preference may be given to such applicants over freshmen. Suitable safeguards should be established to control the quality of students admitted in advanced standing.

3. That educational facilities be reserved for the better qualified students at all levels.

4. That preference in granting admission be given to students who have removed important irregularities of schedules. In cases where students must be admitted with such irregularities, they should be required to make them up as promptly as possible, particularly in summer sessions.

5. In the interest of faculty health and effectiveness, where it has not already been done, that the three-semester or four-term academic year be abandoned at once in favor of the customary two-semester or three-term year, with summer sessions serving only as adjustment periods and not for acceleration.

6. That achievement and/or aptitude tests be given in key subjects: mathematics, physics, chemistry, and English, to students admitted in advanced standing, and that subsequent classes in these subjects or in subjects involving their use be sectioned on the basis of preparation and ability.

7. That this Society take prompt steps to set up an agency for the exchange of teachers.

8. That research and postgraduate work be fully maintained because of the necessity of producing as promptly as possible an adequate supply of recruits for teaching and research staffs.

9. That the former practice of state and municipally supported institutions of admitting students from outside of their states or municipalities be restored as soon as feasible.

Respectfully submitted,
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H. P. HAMMOND, *Chairman*

Report on Present-Day Salaries of Members of the Instruction Staffs of Engineering Schools in United States and Canada*

Foreword

The object of this report is to meet the request of the Administrative Council of the American Society for Engineering Education to make a survey of the staff compensation in the engineering colleges and to give the results thereof, with the supplementary idea of comparing the current compensation with the data on salaries given in the report on "Present Status and Trends in Engineering Education in the United States," which was prepared by the signer of this report and published in 1939 by the ECPD. The present report, which was proposed by the Executive Committee of the Engineering College Administrative Council, is under the direction of the President and Secretary of the Council. Dr. Killian requested the signer of this report to supervise the collection of the data and its analysis and publication, and assigned Mr. M. G. Kispert to assist in the matter. Colonel D. C. Jackson, Jr., who directed the analysis of the material for the 1939 Status and Trends report agreed to participate.

Therefore a questionnaire was prepared to send out to all engineering schools in the United States and Canada inquiring regarding the salaries of the different ranks in the staffs and the conditions of their employment. Its form corresponded with the form used for obtaining this particular information by the ECPD Committee on Engineering Schools in the 1930's. This makes the data in the present report comparable with those on salaries and conditions of work in the 1939 Status and Trends report, which referred more particularly to the years 1934–36. Thus a comparison of the two reports shows the changes in salaries after a period of substantially ten years.

The interest exhibited in this matter is shown to be very notable, because within 36 days of their mailing 148 completed questionnaires had been returned, which was 92.5% of the total number sent out.

Colonel Jackson, Mr. Kispert and I all agree in the interpretations and conclusions given throughout this report, and the interpretations therefore are founded on a large variety of successful experience.

Dugald C. Jackson

Introductory

During the period when the Committee on Engineering Schools of the Engineers' Council for Professional Development was carrying forward its

* Presented at the 55th Annual Meeting A.S.E.E. (Administrative Council), at the University of Minnesota, June 17–21, 1947.

original program of accrediting engineering curricula, the salary level of engineering faculties was generally rather low. Indeed it was sufficiently low to warrant concern that ultimately it would be a deterrent to the continued advance of engineering education, which is essential to industrial progress and the welfare of the nation. Two quotations from the ECPD 1939 report on "Present Status and Trends of Engineering Education in the United States" (hereinafter referred to as the 1939 report) will highlight this point.

"Salaries, extent of conventional teaching loads, and facilities provided for the teaching, stand about stationary except in some notable institutions." (Page 142)

". . . the continuing low level of engineering school salaries in so many of the institutions" (compared with industrial salaries) "undoubtedly affects the distinction of the faculties, since many men of fine qualifications for faculty positions, and tastes which would lead them in that direction, have obligations which press them toward industrial employment rather than entering low-salaried positions in faculties of engineering schools with inadequate financial suport. Many such engineering schools are distant from the centers of great population and large engineering activity, so that inadequate salaries in such locations tend to isolate the teachers from contact with important engineering activities and also prevent resonably frequent attendance on the stimulating meetings of professional engineering societies." (Page 79)

The average of salaries had remained at a low level since the report of the SPEE Board of its study of 1923 to 1929 which was published in 1930 and 1934.

If these statements were true in 1939 at the end of the depression of the 1930's, it is even more important at the present time for the benefit, not merely of engineering education but of the entire profession of engineering and even of the nation itself, that considerable upward revision of engineering school salaries be brought to pass. This is because of the sizeable increases in cost of living and in salaries paid by industry to engineers. This report therefore provides information as to whether engineering schools generally have maintained the level of their faculty salaries commensurate with the increase of cost of living.

Treatment of Gathered Material

For convenience in comparison, the engineering schools utilized in this 1947 report are grouped successively in Geographical Regions and Types of Institutions in the same manner as in the 1939 report. In the 1939 report the effectiveness of institutions was tested by grouping them according to the proportion of the curricula in the program of each institution which had been accredited at that time by the Engineers' Council for Professional Development. We are here dealing with adequacy of salaries compared with cost of living, and the grouping according to accrediting has not been made for the present report. However, a general comparison between salaries and accredited standing is herein made.

Regions I to VII in the present report correspond directly to the seven Geographical Regions in the 1939 report and are as follows: Region I: New England States. Region II: Middle Atlantic States. Region III: North Central States. Region IV: South Eastern States. Region V: South Central States. Region VI: South Western States. Region VII: North Western States. The detailed listing of the states and the District of Columbia in

these seven regions is given in Appendix A, pages 153 and 154, of the 1939 report. In this present 1947 report, Region VIII has been added to include the engineering schools in Canada, Alaska, and Hawaii, which were not included in the 1939 report because the Committee on Engineering Schools of ECPD did not have them on its accrediting list.

In both reports eight type groups are used in accordance with the types of the institutions in which engineering instruction is given. This was determined jointly by the scope and the major source of support of each institution. These types are not separated by sharp lines of demarcation but nonetheless are classed rather readily into the following eight groups:

Privately Endowed Universities

State Universities

Municipal Universities

Privately Endowed Polytechnic Institutes

State Polytechnic Institutes

State Colleges of Engineering and Agriculture

Privately Endowed Colleges

Military Colleges

The military colleges include both those privately endowed and those supported by state or federal funds. A more detailed explanation of these groups is given on page 74 of the 1939 report.

The 1939 report was concerned only with engineering schools within the continental limits of the United States, which accounts for the use of the word "state" in connection with universities, polytechnic institutes, and colleges of engineering and agriculture to designate institutions whose government is under the controls of state legislatures and whose finances to a large extent come from legislative appropriations of state tax funds. Institutions similarly governed and supported but located in United States territories or in the provinces of Canada are included in the 1947 report. Hence the term "state" in this latter report includes all of such institutions whether in the United States, its territories, or Canada, and also at least one institution which is supported by federal funds.

The table below gives the numerical distribution of engineering schools both by geographical regions and by types of institutions for the 1939 and 1947 reports.

Regions	1939 Report	1947 Report	Types of Institutions	1939 Report	1947 Report
I	13	15	Endowed Universities	24	26
II	32	29	State Universities	37	45
III	25	24	Municipal Universities	6	6
IV	21	21	Endowed Polytechnic Institutes	14	16
V	16	16	State Polytechnic Institutes	8	12
VI	15	16	State Colleges of Eng'g. and Agri.	20	19
VII	11	12	Endowed Colleges	15	15
VIII	—	10	Military Colleges	4	4
	133	143		128	143

Note: The 1939 report dealt only with those institutions that had been visited in connection with accrediting.

Out of 135 institutions visited by the Committee on Engineering Schools and of which the curricula were acted upon by October, 1938, one was omitted from the tables because of inadequate information and one had withdrawn from engineering work prior to the 1939 report. The salary charts by regions therefore as of that date deal with 133 institutions. The data in the questionnaires of five institutions were not available for classification by types, which caused the number of institutions in these charts and tables to be reduced to 128. For the 1947 report, questionnaires were received from 148 institutions. Unfortunately, in five cases the questionnaires arrived after the analyses were well under way or the information proved inadequate. Thus the data from 143 engineering schools were used in preparing the tables and charts in this report.

The 1947 data have produced two tables and eleven charts, as compared with one table and five charts on salaries in the 1939 report. In the latter, Chart 5 contains data for two academic ranks. In order that the results may be comparable, the same basic approach has been used in the present report as in the 1939 report. For each of the four faculty ranks (Instructor, Assistant Professor, Associate Professor, Professor) the following are shown: medians of maximum, average, and minimum values of the salaries. The data on Department Heads, which include Chairmen of Departments, have been incorporated with the data on the academic ranks which the individuals hold. The 1947 report also supplies similar information for Department Heads separate from the regular faculty, which was not separated in the 1939 report.

The additional table in this report gives the salaries by geographical regions for the four academic ranks and also separately for the Department Heads. The additional charts in this report show the salaries geographically as follows: By regions—Chart 3, Associate Professors; Chart 7, Instructors; Chart 9, Department Heads; for the ten highest paying engineering schools—Chart 11, Department Heads and the four academic ranks. In this last chart the selection of the ten highest paying institutions was based upon the average salaries of Professors, and therefore they are not necessarily the ten highest paying institutions in the other ranks.

The 1947 salary figures are on the academic-year basis, which is assumed to be about nine calendar months. The information in the questionnaires indicated that to a large extent additional salary is paid for summer teaching, approximately 33⅓ per cent of the salaries for the academic year of nine months for Instructors and Assistant Professors, and 25 per cent of the nine-month salary for Associate Professors and Professors. In view of this fact it was decided to reduce the reported twelve-month salaries (reported by 25 institutions), except those of Department Heads, to a nine-month basis in accordance with the foregoing increases for summer work. Since Department Heads give substantially twelve months' service, regardless of how the salaries are paid, the full amounts of those salaries as reported by the institutions are used in this report when developing medians for Department Heads only, but those salaries were reduced to the nine-month basis when incorporated with salaries of Professors.

Because the 1939 report was based on information gathered by the Committee on Engineering Schools for a

more general objective, the data available at that time were not always susceptible to a reduction to an academic-year basis. Thus some of the salary figures utilized in preparing the tables and charts for that report were for twelve months, although the vast quantity of them were for the academic year. However, even a cursory viewing of the charts in the two tables will show that this does not interfere with the indication of trends in salaries nor invalidate the conclusions drawn from the 1947 data.

Between the gathering of the data for the two reports, three changes have occurred in the organizations or activities of institutions included in the 1939 report, which affect their treatment in the 1947 report. The most drastic of these changes is probably the amalgamation of an endowed college with an endowed polytechnic institute into an enlarged endowed polytechnic institute of greater scope. The other changes have caused two institutions to be shifted between groups in the analysis of data according to types of institutions; from endowed college to endowed university, and endowed college to state university, on account of a shift in a major portion of financial support or of enlargement of university-type activities.

The great bulk of the staff compensation in the engineering schools consists of salaries for instructional duties and research activities directly connected with the educational programs of the institutions. However the engineering schools are conducting considerable research for industry and the government on a contract basis, and for this frequently utilize the part-time services of members of their teaching staffs. This additional activity of engineering schools, related to but not part of their regular educational programs, raised the thought of developing information—

On institutional policy for payment of supplementary compensation, and

On procedures for paying staff members for work on contract research for industry or government.

A consideration of the complexities involved and the time required to obtain the information, which would be reasonably complete and comparable between institutions, showed that an adequate study could not be completed in time for presentation to the Administrative Council at the 1947 annual meeting of ASEE. Therefore it was deemed better to incorporate such a study in the survey to be made of the salaries of staffs of other kinds of professional schools and of engineers in industry.

Discussion of Charts and Tables

Charts 1, 3, 5, 7, and 9 relate to salaries respectively of Professors, Associate Professors, Assistant Professors, Instructors, and Department Heads separately given, shown according to the first seven of the Geographical Regions. Data for Region VIII salaries are given in Table 1, but are not shown graphically in the charts by regions. Charts 1 and 5 are comparable respectively to Charts 1 and 2 of the 1939 report.

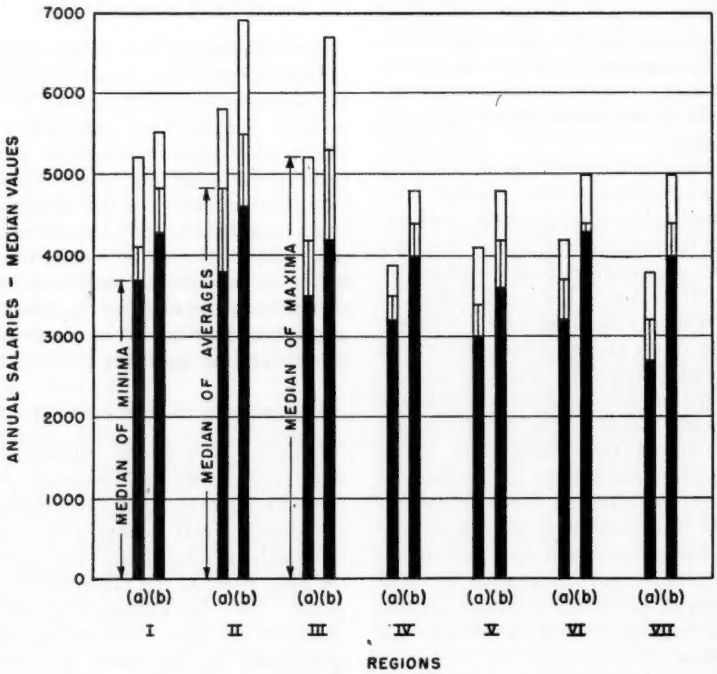
The pattern of salary variation from Region I to Region VIII in 1947 is similar in all five ranks, including the Department Heads, and this is the same general pattern as appeared in the 1939 report for the first seven regions, based upon the salaries in the middle 1930's. Thus the following statement, which was made on page 76 of the 1939 report, holds true also for the 1947 infor-

CHART I. ANNUAL SALARIES OF FACULTY MEMBERS

PROFESSORS
INCLUDING DEPARTMENT HEADS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average, and Minimum Salaries



(a) Salaries based on ECPD Report on Engineering Education published in 1939

(b) 1946 - 47 salaries

mation: "Regions I, II, III cover areas of population and industrial density, and generally speaking of relatively high cost of living, and in these regions the salaries are notably higher than in the others."

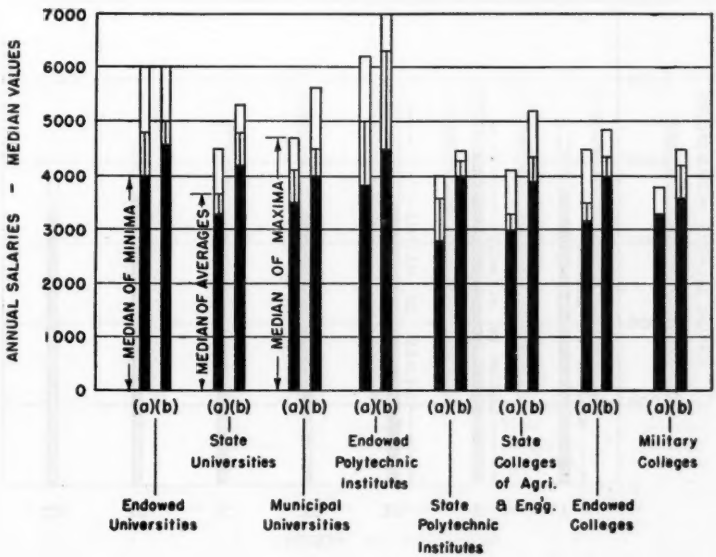
Table 1 contains the information upon which the charts just discussed are based. The graphical form has been used for the presentation of the information on the separate ranks since it more readily shows the variation of salaries between general geographical regions and that the pattern holds true regardless of rank. However, this method does not give an overall composite picture of conditions throughout the nation, and Table 1 was developed

CHART 2. ANNUAL SALARIES OF FACULTY MEMBERS

PROFESSORS
INCLUDING DEPARTMENT HEADS

Engineering Schools Arranged by Types of Institutions

Median Values of Maximum, Average, and Minimum Salaries



(a) Salaries based on ECPD Report on Engineering Education published in 1939

(b) 1946-47 salaries

to provide this general view. This manner of treatment of data is utilized also in the case of the groupings by types of institutions.

Charts 2, 4, 6, 8, 10 of this report give information corresponding respectively to Charts 1, 3, 5, 7, 9 of the report except that the grouping of the results is according to the types of institutions instead of according to geographical regions and the data for the institutions in Canada, Alaska, and Hawaii are included. The relation of the charts in the 1947 and 1939 reports, for comparative purposes, is as follows:

1947 Chart 2	with 1939 Chart 3
1947 Chart 4	with 1939 Chart 4
1947 Charts 6 and 8	with 1939 Chart 5

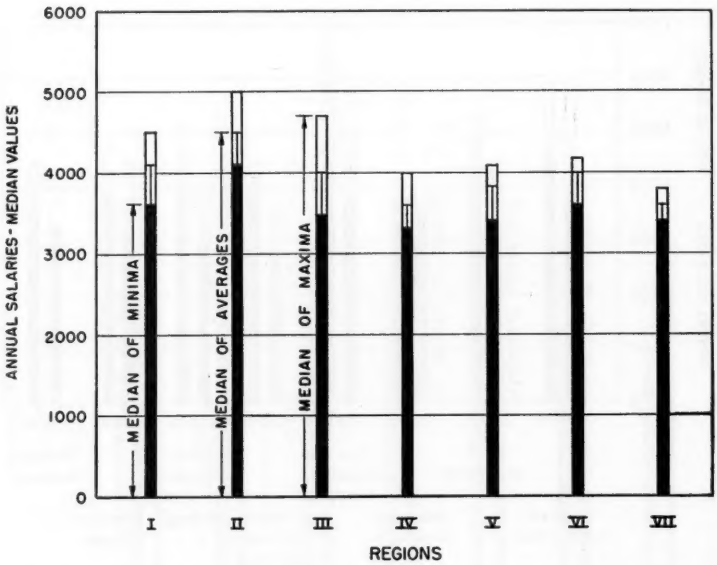
First giving specific attention to the salaries of Associate Professors and Instructors both for the middle of the depression of the 1930's and for the immediate post-war period, a compari-

CHART 3. ANNUAL SALARIES OF FACULTY MEMBERS

ASSOCIATE PROFESSORS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average and Minimum 1946-47 Salaries



son of the corresponding charts shows, between the two periods, that the average increase in salaries of Associate Professors approximates $900 and of Instructors is about $700. It is to be noted that these values are substantially the same as the increase for Assistant Professors and Professors as developed in the discussion of the regional charts. For Associate Professors the greatest increase in the median of average salaries ($1,200) was made by the State Colleges of Engineering and Agriculture and the smallest increase in average salaries ($700) occurred in the Municipal Universities. Similarly, for Instructors the maximum and minimum increases in medians of average salaries between the 1939 report and the 1947 report are respectively $900 by the State Colleges of Engineering and Agriculture and $400 by the State Polytechnic Institutes.

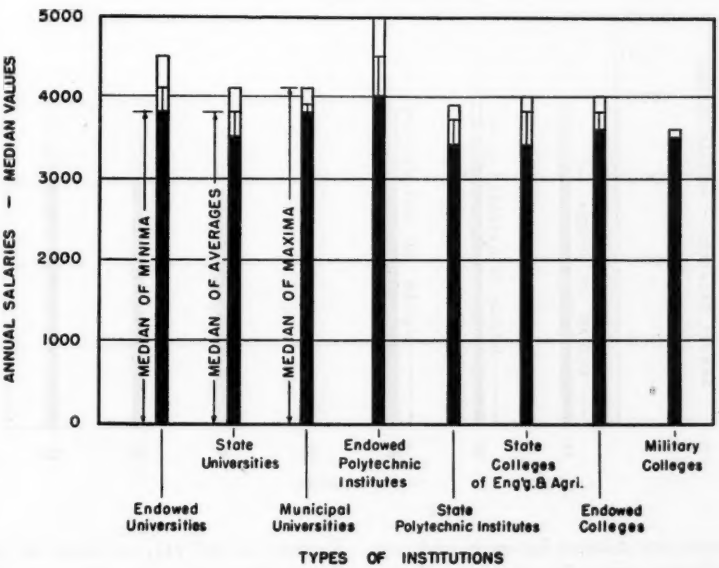
There is not as consistent a pattern from rank to rank when engineering schools are arranged by types of institutions as in the regional grouping. However, the 1939 report shows that the Endowed Polytechnic Institutes and the Endowed Universities had the highest average salaries for the three upper ranks, with the Municipal Universities standing in third place in each case. For Instructors, the Municipal Uni-

CHART 4 ANNUAL SALARIES OF FACULTY MEMBERS

ASSOCIATE PROFESSORS

Engineering Schools Arranged by Types of Institutions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries



versities granted the highest average salaries, with the other two groups following in a tie for second place. The medians of average salaries of all four ranks are definitely lower in the other five types of institutions.

In 1946–47 the pattern of salary variation between types of institutions, for medians of average salaries, is rather similar to that in 1939. However, the State Universities have overtaken the Municipal Universities during the decade between the gathering of the data.

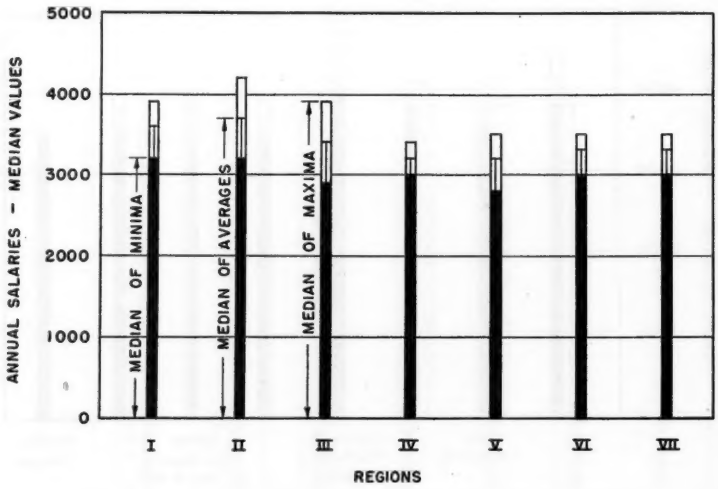
The apparent gain by the lower paying types of institutions in the average salaries of the lower ranks is salutary. However, it seems to be partly because the higher paying types of institutions have not had relatively as large an increase in average salaries. It is rather serious that the overall median of average salaries of Associate Professors in all types of institutions is less than $4,000, of Assistant Professors is less than $3,400, and of Instructors is less than $2,600. These can hardly be considered as satisfactory base incomes (even though for the academic year only) for professional men with the experience and competency required for the specific ranks. The situation is even more serious when the overall medians

CHART 5. ANNUAL SALARIES OF FACULTY MEMBERS

ASSISTANT PROFESSORS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries



of minimum salaries for each rank are considered, especially in view of the large increase in the cost of living.

Chart 10, dealing with the salaries of Department Heads, shows a similar pattern of salary variation, except for medians of averages at Endowed and State Universities. This last is possibly owing to the fact that in many of these universities there is no permanent head or chairman of the department; the department chairmanship is without additional compensation for the administrative duties, being rotated among the members of the department, sometimes even without regard to academic rank. In considering the salaries of Department Heads, it is worthy of note that the medians of average salaries for Regions II and III, as shown in Chart 9 and Table 2, are much greater than for the other six regions.

Engineering school salaries still are higher in the regions where the greater proportion of the total number of institutions are fully or nearly fully accredited. Since the original accrediting program, there have been about the same number of improvements in accrediting in Regions I, II, and III together as there have been in Regions IV, V, VI, and VII combined. Therefore the following statement in the 1939 report still appears to be true:

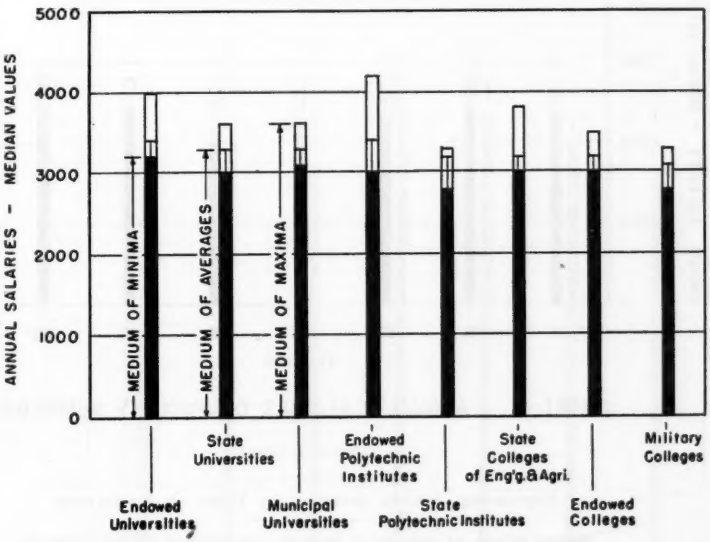
"Since the engineering schools which have a high proportion of their curricula accredited . . . are, in general, those in

CHART 6. ANNUAL SALARIES OF FACULTY MEMBERS

ASSISTANT PROFESSORS

Engineering Schools Arranged by Types of Institutions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries



which the higher salaries are paid in the several teaching ranks, this relation probably is significant. The correlation may come about through the higher salaries enabling these institutions to secure abler engineers and scientists, as well as abler men in the other branches, for all ranks of their teachers. Even though the salaries in the lowest ranks may not be of the highest level, the stimulating influence of opportunity is there—regarding ultimate salary, recognition of creative work, and personal appreciation as distinction is earned." (Page 82)

For the 143 engineering schools as a group, the 1947 data show that the average increase in salary for all ranks, over the salaries for the earlier dates, is approximately the same—less than $1,000. In view of the great increase in the cost of living since 1940, it is important that particular attention be given to the lower two ranks. These men must have adequate income for reasonably satisfactory support of their families without having to resort to activities of a "pot-boiling" character to supply the necessities of life and thereby divert their attention from maintaining their competency in their professional fields. However, since the dollarwise increase in average salaries

CHART 7. ANNUAL SALARIES OF FACULTY MEMBERS

INSTRUCTORS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries

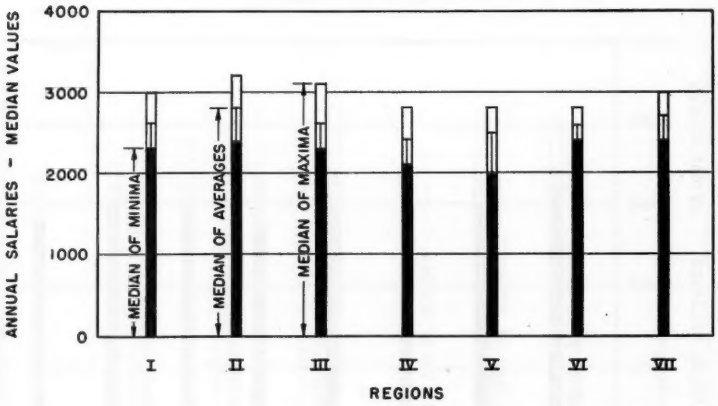


CHART 8. ANNUAL SALARIES OF FACULTY MEMBERS

INSTRUCTORS

Engineering Schools Arranged by Types of Institutions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries

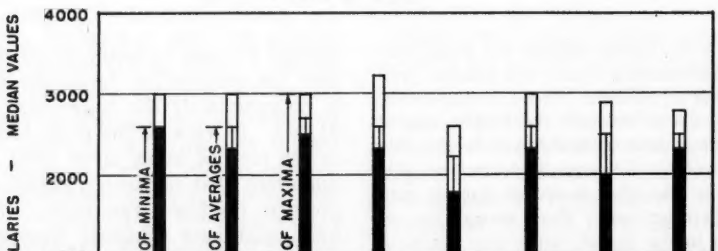
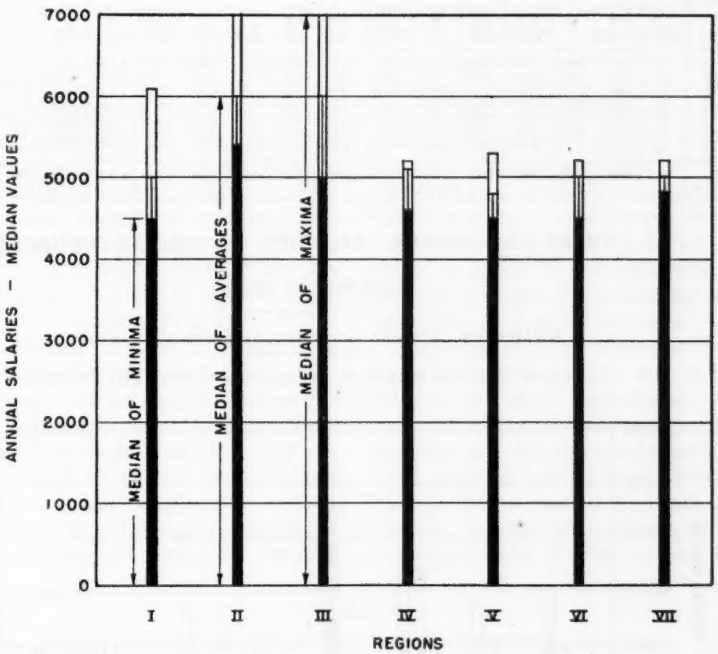


CHART 9. ANNUAL SALARIES OF FACULTY MEMBERS

DEPARTMENT HEADS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average and Minimum 1946-47 Salaries



is substantially the same for all ranks, the differentials between Instructors' and Professors' salaries have been somewhat reduced. This gives even greater force in 1947 to the following statement made on page 79 of the 1939 report:

"It is reasonable to view with caution moderate levels of professors' salaries associated with relatively high minimum salaries in the lower ranks (as found for some institutions), as likely to gather ultimately into such teaching staffs the less creative and more mediocre types of men, there seeming to be only moderate ultimate levels of salary (and probably of achievement) to be reached in at least some of those institutions under their present conditions."

In general the medians of the average values of salaries in the charts are indicative of what the faculty members in each rank are receiving as compensation for their activities during an academic year. This does not include any income received in connection with a part-time consulting practice or from publications or special research work

TABLE 1

ANNUAL SALARIES OF FACULTY MEMBERS

Engineering Schools Arranged by Geographical Regions

Median Values of Maximum, Average, and Minimum Salaries

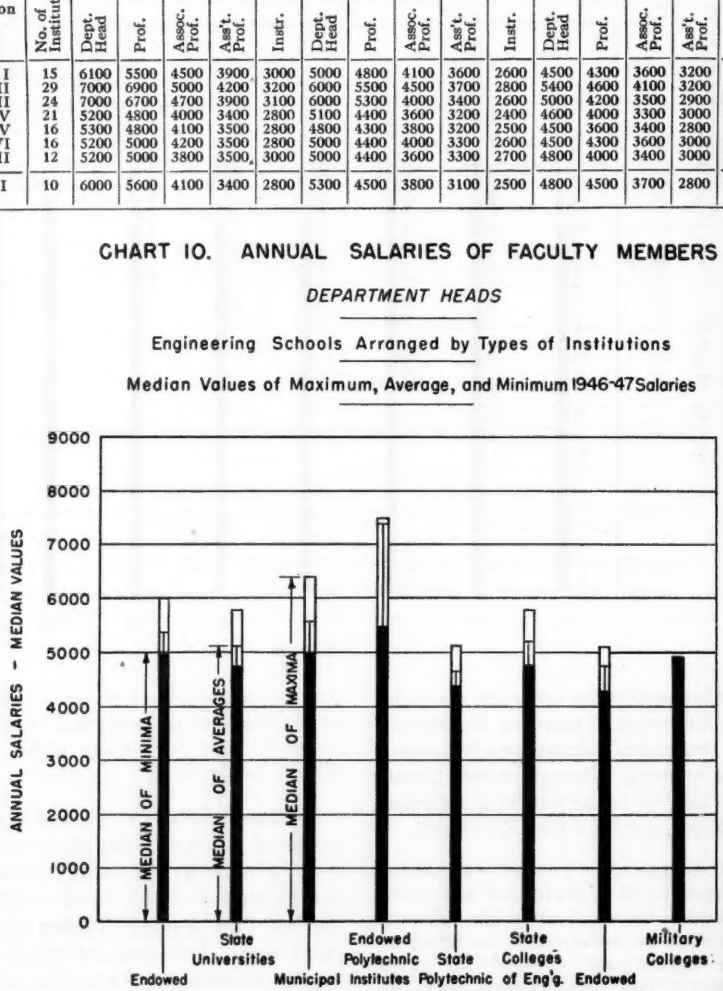
Region	No. of Institutions	Medians of Maxima					Medians of Averages					Medians of Minima				
		Dept. Head	Prof.	Assoc. Prof.	Ass't. Prof.	Instr.	Dept. Head	Prof.	Assoc. Prof.	Ass't. Prof.	Instr.	Dept. Head	Prof.	Assoc. Prof.	Ass't. Prof.	Instr.
I	15	6100	5500	4500	3900	3000	5000	4800	4100	3600	2600	4500	4300	3600	3200	2300
II	29	7000	6900	5000	4200	3200	6000	5500	4500	3700	2800	5400	4600	4100	3200	2400
III	24	7000	6700	4700	3900	3100	6000	5300	4000	3400	2600	5000	4200	3500	2900	2300
IV	21	5200	4800	4000	3400	2800	5100	4400	3600	3200	2400	4600	4000	3300	3000	2100
V	16	5300	4800	4100	3500	2800	4800	4300	3800	3200	2500	4500	3600	3400	2800	2000
VI	16	5200	5000	4200	3500	2800	5000	4400	4000	3300	2600	4500	4300	3600	3000	2400
VII	12	5200	5000	3800	3500	3000	5000	4400	3600	3300	2700	4800	4000	3400	3000	2400
VIII	10	6000	5600	4100	3400	2800	5300	4500	3800	3100	2500	4800	4500	3700	2800	2200

CHART 10. ANNUAL SALARIES OF FACULTY MEMBERS

DEPARTMENT HEADS

Engineering Schools Arranged by Types of Institutions

Median Values of Maximum, Average, and Minimum 1946-47 Salaries



for which pay may come during the academic year. Since most faculty members will be participating in one of these or teaching in perhaps 50 per cent of the summers and receiving additional salary for that, the salaries as stated in both the 1939 and the 1947 reports are a few hundred dollars less than the total earned income on the average for all four ranks of engineering faculties. However, the figures in the two reports are comparable since they are recorded on substantially the same basis.

The average percentage increases in the medians of average salaries between those paid during the middle 1930's (which is the period for the 1939 report) and those for 1946–47 are approximately as follows: Professors 20 per cent, Associate Professors 30 per cent, Assistant Professors 32 per cent, Instructors 36 per cent. Since these percentage changes and those discussed later in this section are computed from increases of *median* salaries, they are not likely to fit exactly the conditions at a particular engineering school. However the methods of computing the salary figures were similar for the 1939 and 1947 data. Therefore the computed percentage changes of median salaries are reasonably close approximations when considering all engineering schools, and are valid for showing the trend. At first glance, these proportions of increase seem rather satisfactory except for the fact that the range between Professor and Instructor is being decreased, which has the disadvantage pointed out earlier. However, a closer scrutiny shows that the percentage increase in the cost of living from the academic year 1935–36 to the academic year 1946–47 as determined from the indices in the Survey of Current Business, Bureau of Labor Statistics, is about 55 per cent, which is much larger than the percentage average salary increase in any rank.

These cost of living indices are based upon the annual budget and cost of living of the better class skilled workmen, whose annual incomes, generally speaking, are commensurate with the lower academic salaries from Instructor through the average of Assistant Professors. It must be remembered that the outgo budget of a professional man,

TABLE 2

ANNUAL SALARIES OF FACULTY MEMBERS

Engineering Schools Arranged by Types of Institutions

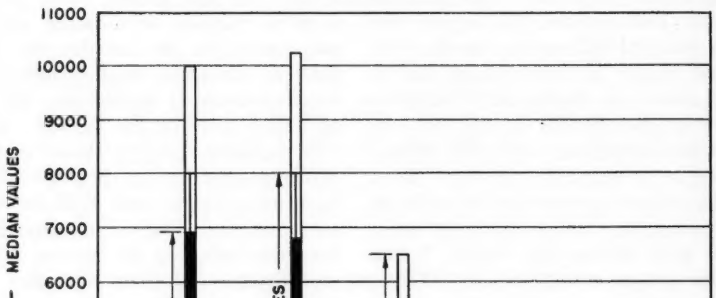
Median Values of Maximum, Average, and Minimum Salaries

Types of Institutions	No. of Institutions	Medians of Maxima					Medians of Averages					Medians of Minima				
		Dept. Head	Prof.	Assoc. Prof.	Assist. Prof.	Instr.	Dept. Head	Prof.	Assoc. Prof.	Assist. Prof.	Instr.	Dept. Head	Prof.	Assoc. Prof.	Assist. Prof.	Instr.
Endowed Universities	26	6000	6000	4500	4000	3000	5400	5000	4100	3400	2600	5000	4600	3800	3200	2600
State Universities	45	5700	5300	4100	3600	3000	5200	4800	3800	3300	2600	4800	4200	3500	3000	2300
Municipal Universities	6	6400	5600	4100	3600	3000	5600	4500	3900	3300	2700	5000	4000	3800	3100	2500
Endowed Polytechnic Institutes	16	7500	7000	5000	4200	3200	7400	6300	4500	3400	2600	5500	4500	4000	3000	2300
State Polytechnic Institutes	12	5100	4500	3900	3300	2600	4700	4300	3700	3200	2200	4400	4000	3400	2800	1800
State Colleges of Agri. and Eng'g.	19	5800	5200	4000	3800	3000	5200	4400	3800	3200	2600	4800	3900	3400	3000	2300
Endowed Colleges	15	5100	4900	4000	3500	2900	4800	4400	3800	3200	2500	4300	4000	3600	3000	2000
Military Colleges	4	4900	4500	3600	3300	2800	4900	4200	3500	3100	2500	4900	3600	3500	2800	2300

CHART II. ANNUAL SALARIES OF FACULTY MEMBERS

SALARIES IN TEN HIGHEST PAYING ENGINEERING SCHOOLS

Median Values of Maximum, Average, and Minimum 1946-47 Salaries



especially a teacher, should include expenses that a skilled workman has no reason to undertake (personal professional library, membership in professional societies and regular attendance at their meetings, etc.). These expenses cause the living cost increase to produce an additional impact on faculty members, especially Instructors and Assistant Professors with their smaller margins. Thus the indices provide a basis for determining the impact of the change in the cost of living on the two lower academic ranks, and a fairly reasonable basis for the two upper ranks as well.

Considering the medians of the minimum salaries paid, the percentage increases between 1935–36 and 1946–47 are approximately as follows: Professors 25 per cent, Associate Professors, 31 per cent, Assistant Professors, 36 per cent, and Instructors 52 per cent. The major portion of the salaries of the younger men on engineering faculties, especially Instructors, must be devoted to the necessities of life (shelter, food, clothing, medical and hospital expenses,

etc.) and these men have little leeway to meet increasing costs of living. Thus the engineering schools have done well to provide sizeable percentage increases, particularly for those receiving minimum salaries. However, a comparison with the percentage change in cost of living shows that the faculty salaries have lost ground in spite of the salary increases, and therefore faculty members are suffering financially, possibly even more greatly than prior to 1940 on the then lower salaries. This may be the cause of the difficulty in certain institutions that now are almost forced to appoint an untried man as an assistant professor, rather than as an instructor who normally is expected to receive more supervision than an assistant professor.

In any activity, whether education, industry, business, government, or sports, it is desirable to establish "par for the course." With this thought in mind, the ten institutions were selected which pay the highest average salaries of Professors. Chart 11 shows the medians of maximum, average, and minimum salaries for Department Heads and the four academic ranks at those institutions. It will be noticed that the median of the maximum salaries for the professorial group is greater than for the Department Heads. This is because three of the ten highest paying institutions do not have the permanent rank of Department Head; the members of the department staff rotate in the responsibilities of chairman of the department without increase in salary. From this chart the medians of average salaries of the ten highest paying engineering schools are as follows: Professors $8,000; Associate Professors $5,400, Assistant Professors $4,200, Instructors $2,900.

These values can be serviceable to the engineering schools when considered as "par." It appears desirable for an individual engineering school to compare the average and minimum salaries at its institution which are paid to each of the four academic ranks with the corresponding values shown on Chart 11—making the comparison both with weight given to the specific living conditions at the location of the institution and also without such consideration. This should produce salary figures which would be to the best interest of the particular engineering school to achieve. If the average salaries at every engineering school approached the values in Chart 11 of medians of average salaries, a much larger proportion of the young engineering graduates would be attracted by the possibilities of the teaching profession. Moreover, there are many men in business and industry with fine qualifications for faculty positions (but with obligations pressing them toward the higher paid industrial or business employment) who would be in teaching positions because of tastes leading them in that direction if the educational salaries were more generally desirable.

Comments

The loss in relative level with respect to industrial and business salaries is not limited to engineering school salaries. Professor Sumner H. Slichter of Harvard University found from a study of the returns from 88 colleges and universities that the academic salaries, including all departments and schools, are on the average lagging even more seriously than those of the engineering faculties. This information is incorporated in his article entitled "What Has Happened to Professors' Salaries Since 1940" in the

Winter 1946 issue of the *Bulletin of the American Association of University Professors,* page 718. Professor Slichter found that, "The sort of two-way communication and carefully organized consultation which one now expects in all progressive and well-administered organizations rarely exists in the administration of the budgets of colleges and universities." He recommended the establishment of a special faculty committee on the budget, which committee would *not* have final determination of faculty salaries but would review the budget and offer criticisms and suggestions, thereby bringing to bear upon the proposed budget the experience and judgment of the faculty in a purely advisory manner. He further recommended the adoption of definite program and time schedules for the restoration of salary scales of pre-war purchasing power.

Professor Slichter found that faculties now are called upon to participate more generally in the formation of educational policies than in budgetary matters. It should be borne in mind that the development of educational policies and a knowledge of financial policies are complementary because the latter supports the execution of the former.

It is evident that desirable increases in salary have been brought to pass since the middle 1930's. However, it is equally as evident that increases in salaries in general are entirely inadequate to compensate for the increase in cost of living that has occurred since 1940. Although a detailed study of industrial salaries has not been made, general information available of salaries paid to engineers by various industrial companies makes it apparent that engineering school salaries still fall too far below those of engineers in industry who have equivalent capacity and exercise responsibilities commensurate in importance.

We must remember that, for the best interest of engineering education and therefore for the best interest of the entire engineering profession and the nation, it is important that engineering school salaries and opportunities shall be such that they will attract the young men with the most creative minds in research and teaching—which minds are backed up with enthusiasm and industry. Therefore it becomes of the utmost importance that general advances of salary scales be made, especially in certain regions and certain types of institutions. In making such advances, except in those institutions which have maximum salaries for Professors of $10,000 or more per academic year, serious attention should be given to the wisdom of increasing the range between the median of average salaries of Instructors and of Professors.

On the Status of Engineering Research in Electronics*

By HARRY DIAMOND

Chief, Ordnance Development Division, National Bureau of Standards

I consider electronics as a science, an art, and an industry. The first phase, science, supplies the basic knowledge upon which electronics is founded. The second phase is the art of engineering research necessary to transform the fundamental knowledge of pure science into practical design factors and instrumentations useful to technology. The third phase is that of applied technology directed to satisfying the material needs of mankind. As of principal interest to this audience, I shall discuss primarily the present status of the second phase, engineering research, and shall attempt to illustrate fruitful directions for further work in this phase of electronics. However, it is not possible to present a clear picture of the state of affairs in electronic research without touching upon the other two phases. The intervention of the war has operated to throw out of balance the inter-relationship normally developed between pure science, research, and commercial application.

The problems currently facing electronics engineers may be stated as follows:

We of the electronics engineering art emerged from the war extreme optimists. Electronics had done such a marvelous job in the war that we felt it had reached a state of advanced perfection and saw unlimited opportunities for its application to peacetime uses. However, upon consideration of our peacetime problems, we began to note a variety of disturbing factors which previously had escaped our attention. Statements by eminent scientists began to appear deploring the lack of progress in pure science during the war and the dearth of trained scientific personnel. We noted further that the normal needs of our economy had been maintained in a state of suspended animation pending the successful conclusion of the war. Meanwhile, the attention of the end users of the products of scientific achievement had been focused on the great accomplishments of science. The nation now awaited the peacetime equivalents of the spectacular wartime scientific applications. The overwhelming scope for the application of new methods, new materials, new tools, and *above all* new ideas to the fulfillment of existing needs was admittedly inspiring; however, we knew that for a variety of reasons the public could not obtain at once, nor could be

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*Presented at the Southeastern Section A.S.E.E., Louisville, Kentucky, April 17, 1947.

promised for the near future, the technological marvels it had come to expect. Finally, the unexpected need for perfecting our national defense at the same time that we drove toward our potential peacetime stride added still further immensity to the job expected of us. It was upon realization of the position into which the pressure of the times had forced us that we electronic engineers first had our rude awakening from the optimism into which we had drifted.

An accurate appraisal of our position requires examination, first, of the problems beyond the control of the research engineer. These are the oversold public, the lack of trained personnel, and the retarded rate of progress of pure science. Once we have considered these problems, it will be possible to proceed to a detailed analysis of the state of affairs in engineering research. This is the most optimistic phase of the picture in electronics, although even this phase is spotty in some branches. From the detailed analysis, I shall attempt to show that:

(1) The emphasis in engineering research during the war has in considerable measure advanced our knowledge of materials, design techniques, and instrumentation, required in applying scientific principles to practical end uses;
(2) For the immediate future at least, there appears to be no discernible dearth of fundamental principles on which to base engineering research;
(3) There is much need for accelerated research to assist in meeting the demands of society; however, by redoubling our efforts we are in position to meet most of the reasonable demands; and,
(4) For the long-pull, we must rely on the pure scientist to widen the gap between fundamental knowledge and engineering application and, perhaps, we must even find ways of helping him do so.

I. Consideration of Problems beyond the Control of the Engineer

Let us dispose briefly of the problem of dissolving, in some measure, the degree of public expectancy of miracle electronic products. A thrilling prospectus has been built up in the public mind, without differentiation between *currently feasible* and *coming* embodiments of useful devices. The exponents of the *electronic age,* no less than the exponents of the *push-button war,* have done considerable mortgaging of the future. The immediate danger is that there may arise an aftermath of disillusionment which will build up considerable sales resistance on the part of the ultimate user. Somehow, the public must be made aware of the actual state of affairs. It is exceedingly important that an exact picture of the true status of electronics, neither overly optimistic nor overly pessimistic, be presented to the public. An encouraging phase of this problem is that the public relations men in industry have become keenly aware of it. Prior to reconversion, it was deemed good advertising to focus the public's attention on promised products; it has now become advantageous to sell the items that are coming off the production line. The latter approach, coupled with the few really new products which are beginning to appear,

should provide an effective stop-gap during which the engineer may concentrate on the perfection of the promised new devices.

Next, let us consider the current lack of sufficient numbers of adequately trained personnel to handle the multitudinous research programs in hand. This is by far the most difficult problem. The principal single factor retarding many a program today is the inability to acquire high-caliber technical personnel. The training of such men is a matter of years of preparation and cannot be extemporized. The war was allowed to interfere seriously with advanced training in the basic sciences and, now, time alone can cure the situation. I am aware of the strenuous effort currently being exerted by the colleges and universities represented at this session towards meeting this problem.

Finally, let us consider the status of pure science upon which we must eventually stake our future. We must, albeit reluctantly, take the word of eminent scientists that the problem here is serious. Quoting from an article by I. I. Rabi [1] on A Physicist Returns from the War, we have the following excerpts:

"By the very success of his efforts in this war, the physicist has been placed in an embarrassing position.

"Industry, with considerable success, is trying to lure him from his academic hide-out with glittering pieces of silver and with the promise of unlimited scientific equipment.

"Our rejuvenated military forces are building giant laboratories (any one of which can use up all of our currently available and really trained physicists).

"The universities hope the physicist will return to satisfy the needs of students.

"The embarrassment of the physicists stems . . . from their realization . . . that in the past five years, apart from the development of certain techniques which may be useful in later research, the progress of the science of physics has been less than moderate.

"With atomic bombs and radar in mind, the skeptics may well ask what the physicist thinks he has been doing these past five years, if not physics.

"To answer them the physicist must attempt to explain the two aspects of his science. There is, first, the creative intellectual activity which constantly pushes back the boundaries of our understanding of natural phenomena; second, the industrial activity which applies the results of scientific knowledge and understanding to satisfy material human needs and whimsies. The first is the science of physics proper, and the second is the side of physics which has been called the inheritance of technology. If the science of physics lags, the inheritance of technology is soon spent. In the war years, the inheritance of technology has been exploited to the point where further substantial progress can come only from an advance in the science of physics."

A corroborative view is that of Raymond B. Fosdick, President of the Rockefeller Foundation, expressed in a newspaper editorial [2] digesting a portion of his Annual Review. Although the field of science discussed is Medicine, the remarks are clearly applicable to other branches of science. I quote:

"Nothing that war touches escapes blight. There is a popular belief that science made rapid progress between 1939 and 1945; but this belief has little basis for support. It is now generally recognized that the feverish activity of scientists in wartime is essentially not scientific. They are primarily engaged in the application of existing knowledge to certain specific and narrow problems.

[1] *The Atlantic Monthly*, October 1945.

[2] *The Washington Post*, March 22, 1947.

They have no time for pure research and their contributions to basic knowledge are infrequent and on the whole unimportant. They are drawing on the reserve of the past. They are using up the supply of basic discoveries which an earlier generation has given them. They are digging recklessly into the stockpile of existing knowledge. The gap between knowledge and use in science is always narrow; the effect of war is to close the gap almost to the vanishing point. . . ."

It is difficult to express correctly a man's philosophy by brief excerpts from a single statement. And yet Dr. Fosdick and Dr. Rabi, in two separate fields of science, say that technology, rather than basic knowledge, was advanced during the war. Both agree that engineering application has caught up with pure science. Both see the need for further advances in basic science for future needs of mankind. For myself, I am inclined to question somewhat timidly the scientist's pessimism on the state of his science. Perhaps I entertain the hope that the situation has improved in the eighteen months since Dr. Rabi's article appeared. Perhaps it is because I am so much impressed with the diversified instrumental tools which electronics is providing in aid to pure science. The emphasis has heretofore been, with complete justice, on how technology leans on scientific advances. The other side of the story, wherein technology contributes to the pure sciences, has in my estimation not been sufficiently pictured. Experimental technique would appear to me to comprise a major factor in modern fundamental research. Investigators in experimental physics, seeking to further the knowledge of the nucleus, the atom and the molecule, appear to me to spend much of their time in developing the instruments with which to carry on their investigations. I will show in my survey of electronics research and development that there was material advancement in basic instrumentation during the war, and even in methods of computation. I believe that these achievements will reflect as material gains to the advancement of pure science.

II. State of Affairs in Electronics Research

The remainder of my discussion will be directed to an examination of the principal branches of the electronics art, with a view: (1) of disclosing the current state of affairs in engineering research in each branch; and (2), of indicating areas in which intensified research appears to be needed.

I find that I must digress briefly, however, in order to define what I mean by engineering research and development and, in that process, to attempt to define science, also. Certainly, if science and engineering are to be mutually exclusive, we as engineers cannot accept Dr. Rabi's possessive reference to the second side of physics which you will recall he labelled the industrial side or the inheritance of technology. Such reference disinherits our profession of what to me represents its most alluring phase, namely, engineering research and development. I consulted the Merriam-Webster dictionary, frankly, with the view of refuting this coup d'état on the part of the physicist. The definitions I liked best follows:

> *Science*—a branch of study which is concerned with observation and classification of facts, especially with the establishment (and, strictly, the quantitative formula-

tion) of verifiable general laws, chiefly by induction and hypothesis.

Physics—the science which deals with those phenomena of inanimate matter involving no changes in chemical composition, or, more specifically, with the most general and fundamental of such phenomena, namely, motion; *i.e.*, the science of matter and motion. Physics is usually held to comprise the closely related sciences of mechanics, heat, electricity, light, and sound, and the branches of sciences devoted to the study of radiations, and of atomic structure.

Engineering—in its modern and extended sense, the art and science by which the properties of matter and the sources of power in nature are made useful to man in structures, machines and manufactured products.

Fortified by these definitions, I feel free to proceed to offer my views as those of an engineer practicing engineering research in electronics.

The truth of the matter is that it is well-nigh impossible to distinguish between *applied physics* and *engineering research*. Activities in electronics during the war present a striking example. As you know, developments in electronic ordnance proved quite spectacular. The proximity fuze and the guided missile are specific examples. The nature of the technical difficulties encountered and of the technical skills required of the workers in this field was not unlike that for radar. An analysis reveals that the structure of representative groups in these two fields was also not dissimilar. Of the 48 senior members of the Ordnance Development Division of the National Bureau of Standards, 29 are classified as physicists and 16 as engineers. As of August 1945, the Coordinating Committee of the M.I.T. Radiation Laboratory comprised 66 members, of whom 45 could be identified as physicists and 15 as engineers. We at N.B.S. are inclined to classify our work as primarily engineering research, whereas I am quite sure that the physicists in charge at M.I.T. considered that they were working in applied physics. Perhaps a compromise term, such as *engineering physics*, might be applicable.

A. A Survey of Electronics

It appears appropriate at this point, also, to introduce a definition of the term *electronics*. I shall quote briefly from a recent address of E. U. Condon, Director of the National Bureau of Standards.[3]

"Electronics has not been given, as far as I know, an officially agreed-upon definition. Generally speaking, . . . it is the science, art, and industry concerned with electrical phenomena involving electrically charged atomic particles, outside of solid and liquid bodies. With this understanding, we have a fairly clear separation of the field from the classical branches of electrical engineering and at the same time a definition that is broad enough not to restrict us to those particular phenomena in which only electrons are involved.

"Electronics is thus a very broad subject. It embraces all phenomena connected with the passage of electric currents through gases and high vacua. Such phenomena are utilized for a wide variety of purposes: the generation of high frequency electric power, its amplification, the control and rectification of electric power at all frequencies, production of electric current from light sources,

[3] *Electrical Engineering*, April, 1947.

and production of light from electric currents (including X-rays and gamma rays as special forms of light). Phenomena associated with the propagation of radio waves in the ionosphere are of course also included, as is the study of cosmic radiations from interstellar space, and special means for producing beams of atomic particles of high energy for the study of nuclear physics."

Based on Dr. Condon's summary definition and partly on the body of his address, I present herewith a partial list of branches of electronics of interest to the engineer:

(1) Radio communication and broadcasting, including television and facsimile.
(2) Electronic ordnance, including radar fire-control, electronic controls for guided missiles, proximity fuze, and electronic controls for underwater torpedoes.
(3) Radio navigational aids, including radar, loran, and other sea and air navigational aids.
(4) Electronic power conversion, including dielectric and inductive heating.
(5) Electronic instrumentation and controls, including special instruments for physical, chemical, medical and biological research and practice, and the general concept of the servo-mechanism
(6) Electronic devices for mathematical computation.

Basic to all of these branches are the electron tube and the electronic circuit. The diversification of form, function, and complexity of each is well-known. Each presents a fruitful field for research basic to the entire art. Knowledge of the properties and design of electron tubes and electronic circuits was materially increased as a result of the major application of electronics to war purposes. It is only necessary to mention the rugged subminiature proximity-fuze tube, the magnetron, the klystron, the traveling-wave amplifier tube, the image-orthicon, the "memory" selectron, and the hydrogen-thyratron, to call to mind the degree of recent effort in the electron tube art.

Similarly, the printed circuit, the microwave plumbing, the resonant cavity, the dielectric-heater electrode, new pulsing techniques, and various forms of new antenna, illustrate some of the activities in electronic circuits. Associated with tubes and circuits may be found practically every component and instrument familiar to physics, chemistry and engineering. Despite the wartime accomplishments, intensive research effort is now in progress, and will be required for many years to come, towards furthering the knowledge of fundamental phenomena in these fields.

For example, in electron tubes the oxide coated cathode is used extensively, yet very little is understood about the mechanism of electron emission from oxide-coated surfaces. Although increased understanding of the phenomena is of basic importance generally, it is particularly urgent in the case of pulsed, high power tubes. It is encouraging to report that research projects on thermionic emission from coated surfaces are under way in several institutions, but in this field there is little doubt that applied research is treading close on the heels of fundamental science.

Also, within the electron tube, it must be admitted that the nature of secondary emission, both from metallic and dielectric surfaces, and the nature of ion formation are subjects about

which we really know very little. Although much applied research, involving mainly circuitry, can be done with tubes we now have, further advances in the tube art are greatly dependent on continued discovery about emission and ion formation.

B. Radio Communication and Broadcasting

During the war, great advances were made in the knowledge of the factors affecting the propagation of radio waves throughout much of the radio-frequency spectrum. The influence of the ionosphere and of the troposphere under varying meteorological conditions is now much better understood. The importance of such increased knowledge in the physics of radio propagation can hardly be overestimated. It is now possible to prepare predictions of conditions affecting radio propagation sufficiently well in advance and of an order of accuracy such as to be extremely useful to the radio communication and long distance aerial and sea navigation services. There is ample room for more basic research, but certainly the war caused no halt in this field of study.

Radio communication and broadcasting cannot escape benefit from the increased knowledge of radio propagation and from the advances in tube, antenna, and circuit theory and technology resulting from the major application of electronics to war purposes. It might be said that the application of television, frequency-modulation and the like to the entertainment services was held up, but there appears to be no technical reason why these services should not attain major proportions very promptly. For example, now that the Federal Communications Commission has ruled that more research is needed on color television, the industry is turning to development of nation-wide black-and-white service. Concurrently, basic research on electronic methods of color television should proceed.

I shall not attempt to detail possible avenues for research in this oldest field of electronics.

C. Electronic Ordnance

The branch of electronics called electronic ordnance is primarily a product of World War II. It has a short but brilliant past and a great future, but presents many technical challenges. Naturally, I cannot discuss these in detail because of the necessary military security restrictions imposed. However, merely a list of some of the applications, such as radar fire-control, electronic controls for guided missiles and underwater torpedoes, the proximity fuze, and electronic bomb and rocket directors, provide an indication of the scope of activities in this field. A further indication is that officers of the Army and Navy ordnance development agencies now sit on technical committees discussing electronic tube and component developments. Research in this field cuts across the electronics art and, at the same time, is intimately associated with several other arts. In certain applications, such as the proximity fuze, the development of processes, instrumentation and techniques for furthering mass production is nearly as important as the development of the devices themselves, since during the latter months of the war some 25 per cent of the capacity of the electronic industry was devoted to the manufacture of this device.

The retreat of technical men from this branch of electronics, as from other military research activities, is a

source of much concern to those responsible for our national defense. The technical challenges are such as to require personnel of highest caliber and training. The results of research in this field will undoubtedly prove of value to other branches of electronics, such as radionavigational aids.

D. Radio Navigational Aids

The public could be entertained by wired programs if radio channels did not exist. But an airplane, particularly during adverse weather conditions, must rely very largely on radio aids. This then is a true example of the application of science to extend man's power to see, hear or do beyond his own unaided capabilities.

It is a curious paradox that many such applications are based on too literal an interpretation of this aim and thus require the use of man himself in their ultimate utilization. This element was a necessary characteristic of many of the wartime radio and radar developments and its effect must be carefully considered when evaluating them for use as peacetime air navigational aids. The human factor in radar search, in voice communication, in underwater detection and in loran navigation was an important one. Upon the power of the eyes or ears to make a fine discrimination often depended the outcome of a battle. Psycho-physicists were busily devising means for increasing the sensory margin of the operator in order to get the most out of the man-machine combination. This was highly commendable under the circumstances and may similarly be useful in application to industrial practices.

It should be clearly evident, however, that radio aids to air navigation must place as little reliance on sensory margin as is humanly possible to achieve. The conditions of safety and reliability are so stringent that an accident rate during 1946 of 1.2 passenger fatalities per 100-million passenger miles in domestic air operation could be sufficiently over-shadowed by a few foreign accidents as to cause a Senate investigation. Although the record cited for domestic operations for 1946 is impressive, the actual situation leaves much to be desired when one considers the air congestion at and around airline terminals under adverse weather conditions; and this with only 650 airplanes in scheduled operation. The future of air transportation calls for much better scheduling of a much greater air fleet with at least an equal record of safety. Viewed in this light, the requirements imposed on a basic system of radio aids are tremendous.

Ultimately, it appears necessary to bypass the human navigator altogether, and to apply the navigational intelligence directly to the controls of the aircraft. In considering the division of responsibility between ground controllers and crews of aircraft, it will be seen that the ground controllers should establish the flight plan which is to be followed, and that the air crew should be given sufficient information to carry out that plan with minimum reference to the ground controllers. In a completely automatic system, the air crew should have means for correcting the flight of the craft if it does not adhere to the desired plan, or for deviating from the plan in case of emergency. The ground controllers should have continuous automatic monitoring of the position of each craft in flight and of the degree of its adherence to the prescribed plan.

Automatic ground computers and associated automatic pictorial display of the monitored data will undoubtedly be required to provide for efficient traffic control. Rapid communication between the air crews and the ground controllers will obviously also be essential.

Today no basic system exists which can conceivably do a 100 per cent job of this sort. This is clearly recognized by the aviation industry and by the responsible governmental agencies of the world. It is to the credit of all these, however, that really constructive measures have already been taken, on an international basis, to assess the systems now available, to standardize those fitting into an ultimate plan, to promote the development of other systems applicable to this plan, and, finally, to define the functional requirements for the elements of such an overall plan. Nevertheless, we have a state of affairs where extraordinary needs exist for radio aids which are, however, not available in their preferred forms. An intense effort of research and development is accordingly indicated, if the important air transport industry it to attain its potential proportions.

In the few minutes that I can devote to this subject, I shall attempt to accomplish the following objectives:

(1) To review briefly the present state of development of radio aids to aviation;

(2) To assess the influence of wartime experience upon them; and

(3) To indicate the areas wherein research development work is vital. (I have already discussed the aims to which such work should be directed.)

A digest of the conclusions and recommendations of the international body (Provisional International Civil Aviation Organization) which met in Montreal in December 1946 to consider this problem will serve very closely for my presentation.[4]

The ultimate goal adopted was to provide a unified system of radio aids comprising *communication, navigation, traffic-control* and *collision-warning* services suitable for use under all flying conditions and in all parts of the world. Functional requirements were set up for the basic elements of this ultimate system but, recognizing the long range aspects of fulfilling such requirements, a set of immediate objectives was adopted for interim application.

The basic *functional requirements* were directed to the continuous safe and efficient movement of air traffic, founded on effective navigational aids along all portions of the route to be flown, including take-off and landing. Emphasis was placed on an integrated system with automatic features wherever possible, but with considerable freedom for deviation from the prescribed plan, when essential, on the part both of the air crew and of the ground controllers. Visual display of information to the air crew was also emphasized. Even in communication, it was recommended that long instructions be recorded either by facsimile, by teletype, or by indicator signalling. Radar was found to have its principal

[4] Final Report from the Chairman, C. O. T. Division (Radio Technical Division) to the Chairman, Air Navigation Committee, Provisional International Civil Aviation Organization Doc. 2553 C. O. T./28, dated Nov. 29, 1946, presented to the Council of P. I. C. A. O., for consideration at the Dec. 1946 Meeting in Montreal, Canada.

field of application in traffic control and collision prevention aids, although having auxiliary functions in short distance radio aids and in landing aids. Because of the increasing range of operation and speed of aircraft, short-range aids as well as landing aids were conceived to be increasingly associated with the traffic control system. Accordingly, automatic features were particularly stressed for these aids. Major facts to be highlighted are:

(1) that the systems found most applicable for the short-distance and landing aids were developed well before the war;
(2) that, in the primary fields of application of radar, considerable development will be required before the inherent functional requirements can be met practicably; and
(3) that for long-distance navigational aids, LF loran, developed during the war, is undoubtedly the best available although not readily adaptable to automatic navigation.

For interim application it was found possible to define certain *immediate objectives* which may be fulfilled by currently available systems. The more important definitive recommendations were:

(1) The ILS system of landing aids was standardized and recommended for installation at all airports used by international airlines at the earliest possible date and in any event not later than January 1, 1951. Such installations were defined to include a VHF runway localizer, a VHF guide path transmitter and three VHF markers. Provisions were made for substitution of a phase comparison localizer for the equisignal type any time after January 1, 1951, and for the use of medium frequency D. F. beacons at the approach and middle marker beacons, if desired. Further provisions were made for the additional use of Ground Control Approach radar as an aid supplementary to the standard system where local conditions warranted. (In the interim report of the U. S. Senate Committee on Interstate and Foreign Commerce, ILS and GCA are recommended for joint installation at the principal U. S. airports).[5]

(2) The VHF omnirange, in combination with distance measuring equipment (DME), was recommended (but not standardized) for use on all international trunk routes where short distance navigational aids are required. The omnirange is to be of the CW phase comparison type, so that where the runway localizer of ILS is of that type, the same aircraft receiving set may be used. DME is the usual radar transponder beacon type. Considerable leeway was left to individual countries, for use on a regional basis only, of such aids as are now available or under development; for example, the Australian multitrack pulse range together with DME, the American low-frequency omnirange, etc.

[5] Interim Report of the Committee on Interstate and Foreign Commerce, U. S. Senate, titled "Investigation of Air Safety," Feb. 22, 1947. (Senate Report No. 36, 1st Session, 80th Congress.)

(3) LF loran was recommended for installation to investigate coverage of critical areas within regions indicated on priority lists, such installations to be limited to those necessary to meet the operating requirements on international air routes in those areas. Standard loran and other existing long-range navigational aids, such as Consol, were recommended for retention or extension to meet traffic requirements.

The P. I. C. A. O. plan of ultimate functional requirements and immediate objectives for interim application points up an immense field for engineering research and development. The central problem for future development is that of short-distance and terminal handling of traffic. To this problem must be drawn much of the advancing art of guided missile controls, radar, and automatic computing methods. Here, the results of military research may be applied to current civilian needs.

E. Electronic Power Conversion

This represents the volume-sales branch of industrial electronics. Applications of electronic power conversion are extremely diversified, including rectification, electroplating and electrolytic processing, and frequency conversion. A very substantial fraction of the electric power generated during the latter years of the war was converted to direct-current by mercury-arc rectifiers for the electrolytic refinement of light metals. Many other industrial processes utilize power converted from the 60-cycle supply by means of electron tubes and other electronic devices. *Frequency conversion* is a particularly important form of power conversion; for example, the 60-cycle power is converted to power at frequencies up to hundreds of kilocycles for *induction-heating* and up to hundreds of megacycles for *dielectric heating*.

In this country, existing installations of induction and dielectric heating equipment alone employ more large electron tubes than are used in radio broadcasting, communication, television, etc., throughout the world. Potential requirements for electronic heating are expected to increase this margin by a large factor. Indeed, major competition is now in progress between the electrical utilities and manufacturers and users of electronic heating equipment on the one hand and radio communication and broadcasting interests on the other hand for the assignment of radio frequencies. The problem lies in the fact that very important new industrial processing methods may be endangered and corresponding valuable electrical loads may be lost to the electric power companies if too stringent regulations are imposed on the frequency stability and/or electrical shielding of such industrial electronic equipment in order to minimize interference with the communication services.

For maximum exploitation of new applications, more information is required on optimum and usable frequencies for the diversified products or materials which may be processed by electronic heating. The Federal Communications Commission has recently assigned a wide range of spot frequencies for this type of equipment. Instrumentation and data to allow the user to determine the optimum frequency for his product are vitally needed.

In this field of power conversion,

manufacture of the product as well as use of the process is highly decentralized. The capital required in manufacture is relatively small because the components (exclusive of tubes and power transformers) are inexpensive and no heavy machinery is required. There is considerable room for the exercise of individual ingenuity and inventiveness to find the solution to specific application problems. Because of this situation, the industry has great need for authoritative information on pertinent design factors. For example, one manufacturer considers his outstanding problem to be the design of a 1,000-KW unit which will operate efficiently with loads varying rapidly from 5 to 150 per cent of full-load rating.

It will be evident to this audience that the college engineering research laboratories can make vital contributions to this field. On its part, the National Bureau of Standards is investigating wherein it may be of service, within its prescribed sphere of activities. The work involved is straightforward engineering development and can in no sense be considered to be awaiting new basic scientific discoveries.

F. Electronic Instrumentation and Controls

This is a field of application of electronics which has virtually no limits. It advanced very materially during the intensive wartime exploitation of electronics. As might be expected, *electronic instrumentation* serves much the same purpose in industry as in science. The essential difference is that, in manufacturing, the measurement or analysis is made in connection with controlling the quality of a process or of a product; whereas, in scientific investigations, greater accuracy and rather more basic information are often sought. Electronic instrumentation provides a whole series of new approaches without which recent advances in science and engineering would have been well-nigh impossible.

In simpler applications of electronics to measurement and analysis, the basic elements of the instrument comprise a transducer for changing the function measured into an electrical impulse, an amplifier, and an indicator. For instrumentation of the type indicated, there is need for the development of standard basic elements which may be combined to perform a wide variety of functions.

In many instances, telemetering is required for transferring the indication to a point remote from where the actual measurement is made. An example of this is the analysis of stresses in airplane structures by instrumental, transducing and amplifying means on the airplane with the recording means on the ground. Telemetering is then accomplished by a radio link. Until recently, the radio sonde was perhaps the best known example of the use of electronic telemetering in instrumentation. Currently, our knowledge of the physics of the air is being expanded by instrumentation, including telemetering, carried into the upper atmosphere by the German V–2 rocket. In its tests of the missile in New Mexico, the Army Ordnance Department has afforded participation by a group of scientific organizations to conduct parallel investigations on the physics of the upper air.

The tremendous scope for electronic instrumentation can hardly be overemphasized. Precise measurement is the essence of science and of industrial processing. Electronic instrumentation affords a flexibility virtually be-

yond that of previously known means. There is ample room for research work in basic electronic instrumentation to exploit fully its potentialities.

There is a special class of large electronic instruments, developed primarily by the scientist and of particular value to the experimental progress of basic science. This class of tools includes mass spectrometers for chemical analysis and process control, devices for accelerating electrons and ions, and devices useful in the application of radioactive elements to industrial purposes and to medical research and practice. One needs only to mention the electron microscope, the cyclotron, the betatron, the synchrotron and the linear accelerator to indicate the scope of this type of application. I saw recently a list of such instruments being installed, or planned for installation, in scientific institutions of the United States; the numbers and the ratings in hundreds of megavolts were impressive. I would judge that the costs in megabucks were equally so. The outlook is for great scientific advances from the use of these installations. The scope for research on improving instruments of this type, or devising new ones, would appear to be large.

Electronics control to quote a recent article in *Fortune*[6] "increases the efficiency, safety, and control of power, flight, machines, and automatic processes, and is in wide expansion." The same article states:

"Probably less than 5 per cent of industry is equipped with electronic devices that it could profitably use. If it were fully equipped, the effect might be like that of transforming the average workman so that the power of his senses, and his mental and physical endurance, were multiplied a thousand times."

As in the case of electronic instrumentation, the diversification of potential applications of electronic control devices is awesome. The relative importance of specific types of application is necessarily based on the extent of their utilization. For example, a large majority of the automobiles produced in Michigan have their frames welded by machines using a special type of electron tube, the ignitron, which controls the welding process.

A typical use of electronic controls is for maintaining constant temperatures in the furnaces of the metallurgical industry. The critical factor in this application is the degree of accuracy attainable. This involves devices for the measurement of temperature, electronic devices for translating the measurements into control forces and means for adjusting the furnace temperature in response to the control. This type of "closed circuit" control is typical of a new and large class of devices known as *servo-mechanisms*. The advent of electronic sensory elements and amplifier equipment has been a tremendous step forward in the development of the servo-mechanism. The use of servo-mechanisms is as widespread as the need of industry for accomplishing correction of changes in some condition in response to detection of such changes. In this sense, the servo-mechanism has come to be defined and analyzed as a type of feed-back amplifier. In certain applications, it is evident that the amplification, conversion, and transmission of forces involved may be accomplished mechanically. However, the flexibility afforded by electronic controls, including the readier means avail-

[6] *Fortune*, Vol. 33, Nos. 1 and 2, Jan. and Feb., 1946. American Productivity, I and II, by Charles B. Walker.

able for correcting time lags, hunting, etc., accounts for the invasion of electronics into this field.

A fertile sphere of application of electronic controls lies in industrial processes which require close control of several conditions and of the constituent ingredients to secure a satisfactory product. Often the end product is analyzed at frequent intervals and, if not of desired quality, rather involved computations are made to determine the requisite adjustment of conditions or ingredients. It is within the possibilities of the present state of electronics to accomplish the analysis, the computations and the adjustments automatically so that the quality of the product may be kept continuously at the highest possible level. The overall electronic system may be considered a super servo-mechanism since, in the sense of the feed-back loop definition, departure from desired quality of the product is detected and automatically minimized.

It will be evident that there is great need for vigorous exploitation of this field in cooperation with industry. Such work will necessarily involve the development of new methods and the systematization of fundamental data and pertinent design factors.

A factor which is believed to be operating against more widespread application of electronic controls in industry is the relatively short life and non-ruggedness of electron tubes and circuitry. In the application of electronic devices to the control of machinery or processes, it is important that maintenance requirements be minimized, particularly since many industrial plants do not have electronic engineers available.

Miniaturization of electronic circuits and components is also highly necessary in certain industrial applications. An electronic control device should form an integral portion of the unit it controls. It should, furthermore, constitute a readily replaceable unit. Only then will it be completely accepted by industry. Fortunately, the technology of the proximity fuze has gone a long way toward the ruggedization and miniaturization of electron tubes, circuits, and components; these techniques are now being adopted rather widely in the industry.

G. Electronic Computing Aids

The electronic digital computing machine is the latest example of the speed and flexibility afforded by electronic methods. I consider that the advance made in this field during the war represents one of the most important scientific achievements of the past decade. To introduce this subject, I quote from Dr. Condon's address:[7]

"Only those who are skilled in mathematical physics realize how very limited is man's ability to obtain analytical solutions to important problems in applied mathematics. Great as has been the progress of the past century, the time has come when many problems of great importance, especially in hydrodynamics, aero-dynamics and meteorology, can only be handled by methods based on elaborate arithmetical computation. For a good many years now it has been the practice to introduce artificial and unjustified approximations into the setting up of many such problems in order to reduce them to a form tractable by our limited analytical attainments. As a result one is often confronted with this unsatisfactory situation: A theoretical calculation is made and the results are compared with experimental data and discrepancies are found. The question now is, are these discrepancies

[7] Electronics and the Future, Oct. 3, 1946.

due to an improper physical formulation of the problem, or due to the inadequacy of the mathematical methods used in making specific calculations from a correct physical formulation? Such a situation is clearly intolerable.

"On the other hand, calculations required for problems of current interest are so elaborate as to require many man-years of work by skilled computers. Aside from the cost involved, such a situation slows down progress because one has to wait too long to get an answer by old-fashioned hand-operated computing machines.

"A good deal of progress was made during the war in opening up the field of application of electronic methods to rapid calculations. . . ."

Federal activity in the computing field stemmed principally from the efforts of the War and Navy Departments to acquire computing machinery constructed specifically for critical wartime computation needs. There were three significant developments in this period: (1) an electromechanical computing device (the IBM sequence controlled calculator) of the Harvard Computation Laboratory, (2) relay type computing machines of the Bell Telephone Laboratories, and (3) an electronic computing machine (ENIAC) of the Moore School of Engineering of the University of Pennsylvania.

The application of such machinery ranged from numerical solutions of problems involving nuclear physics, hydrodynamics, electromagnetic wave propagation, the computation of firing tables, the application of statistical sampling theory and the like, to inclusion as components in missile flight simulators and fire control apparatus. The need for high computation speeds was extremely urgent, and the digital machines developed to meet it played a significant role in shortening the conflict.

A significant result of the intensive development and use of the high-speed computing machines during the war is that designers have been provided with operating data that would normally have required many years for accumulation. Experience now indicates rather clearly both the merits and the deficiencies of existing machines. The consensus of expert opinion is that the potentialities of electronic machines surpass those of the electromechanical and relay types and that further development should probably be limited to the electronic field. It is also agreed that an unparalleled opportunity for design improvements is at hand and that electronic digital computing machines can be constructed that will far exceed the ENIAC in speed and flexibility.

Electronic digital computing machine development requires the cooperation of two groups: mathematicians, responsible for the mathematical performance requirements and for organizing the mathematical logic; and physicists and engineers, responsible for developing the basic functional organs and for the engineering design integrating these organs into a unit capable of performing the prescribed tasks. In the complexity of circuitry, this field probably exceeds radar. There is ample room for new ideas and techniques. The demands for such equipment promises to become of significant commercial volume.

Great need for electronic computing aids exists in industry, in the universities, and in the Government. In industry, for example, the super-servo system cited in connection with electronic controls will require automatic computing elements of varying complexity.

The need in civilian agencies of the Government arises largely from the new complexity of problems in the social and physical sciences. For example, the Census Bureau needs to speed up the processes of sorting and analyzing field data involved in the preparation of monthly reports on labor force and of import and export statistical reports. In typical instances, the number of records studied may run to several million. Speed of report is, therefore, essential. The Census Bureau has other computational problems which may be carried out practically only through the aid of electronic computing machines.

The Weather Bureau probably represents the outstanding example of need by a civilian agency for electronic computational aids. Here, the mass of three-dimensional weather data collected daily over extensive geographical areas must be interpreted to provide reliable weather forecasts. The dynamic theories of weather forecasting have apparently outstripped the capacity for computations required to apply these theories. The Weather Bureau is actively engaged in the study of problems the solution of which might be facilitated through the use of electronic computing machines. There is need for parallel study of basic computing systems and equipment designed to carry out the required computation.

Other civilian agencies having possible present or future needs for electronic computing machine facilities include the National Bureau of Standards, National Advisory Committee for Aeronautics, Civil Aeronautics Administration, and Social Security Board. For example, the Bureau of Standards requires the use of the most advanced types of computational aids in connection with a number of its scientific investigations as well as in its work on mathematical tables. Moreover, a proposed computation center to be operated by the Bureau will increase its requirements for such computational aids.

I shall not attempt to outline the present activity on electronic digital computing machines except for the mention of a partial list of developmental agencies which includes the Institute of Advanced Studies at Princeton, the Moore School of Electrical Engineering, the National Bureau of Standards, Harvard University, and the Massachusetts Institute of Technology.

III. Conclusion

In conclusion, I trust that you will agree with me that an examination of the actual state of affairs points to a great future for electronics and to a very fruitful field for engineering and physical research. Anyone who was present at the recent great convention of the Institute of Radio Engineers, where more than 11,000 engineers and physicists attended the technical paper sessions and some 14,000 the exhibit-packed Grand Central Palace, cannot have avoided catching some of the enthusiasm with which many of us are imbued. The emphasis of other scientific and technical societies on electronic matters emphasizes the importance of this branch of science. The history of the development of atomic energy teaches us that any great development will carry along with it important tasks for electronics. If we get an atomic power industry in the near future, it will be largely electronic in character because of the obvious necessity for equipping these plants with completely automatic control devices.

The Engineer Hates Grandfather's Horse

By W. GEORGE CROUCH
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and ROBERT L. ZETLER
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Dean E. K. Hobhouse, of Upsilon University, strode into the Chancellor's office. "Mr. Chancellor," he sputtered after the initial handshake, "Look at these statistics! Out of 200 freshmen enrolled in the School of Engineering who are taking English I, there are 18 per cent F's and 43 per cent D's. Now what the hell's the matter? Are our students, who get average or above average grades in their mathematics, chemistry, and physics so dumb that they can't master their own language, or are the standards of the English Department too high? Or maybe we have too many damned aesthetes teaching our boys!"

The complaint of Upsilon's Dean is a standard one in almost every university in the United States. The engineering teacher—and at times, even many English teachers of engineering students—realize that our present teaching of English to the embryonic engineer is sadly deficient. In the typical American university, the English Department has a polite condescension towards the School of Engineering. The English teacher himself, trained by a graduate school as a specialist in literature or in composition of the aesthetic type, often finds himself in opposition to the material to be taught the engineer and to the engineer's viewpoint. Having interests which are primarily artistic, he looks upon the aims of the potential engineer as too practical.

If he is assigned to teach a course in freshman English for engineers, he may give the students subjects for compositions which are divorced from their interests. Such subjects might range from a description of grandfather's old bay horse to the taste of celery, but he will never suggest that his students explain the operation of a governor or the use of an industrial incentive system. He fails to motivate his students through their existing interests.

The best composition is done when the writer has enthusiam for his subject, but the topics most often assigned by English teachers to technical students do not stir this enthusiasm. Is the average English teacher, then, fulfilling his obligation to the engineering student?

Unfortunately members of English departments look upon their schedules in schools of engineering as "necessary busy work." Heads of departments are only too pleased to farm out this work to any luckless graduate assistants who may be cajoled into taking

the job. The best men are occupied with teaching their favorite courses in the College to students who may some day become English teachers or who may develop an abiding enthusiasm for literature. The tyros who take the engineering student in hand often regard their job as distasteful, to be endured until they can get a teaching schedule related to their special interests.

What can be done to improve the teaching of English to engineers?

There are at least two possibilities. The first is the creation in the School of Engineering of a separate Department of English. Such a department should have its own head; it should be under the jurisdiction of the dean of the School of Engineering. Its faculty should be recruited from men who have been trained in engineering as well as in English. The courses should be planned to appeal to the primary interests of the engineering student.

Both the faculty and the students should benefit by this plan.

First of all, it would effect a closer cooperation between the English faculty and the engineering faculty. English would become as much a part of the School of Engineering as the Department of Mines and Mineralogy is. And the engineering teacher, knowing the sort of writing his students will need when they become professional engineers, will be able to give valuable advice to his colleagues in English in the planning of courses in composition. He will, moreover, frequently be in consultation with the English teacher concerning the type of literature which the engineering graduate ought to be familiar with.

Separation of the Department of English in the School of Engineering from the Department of English in the College will make it possible for the instructor to become a specialist in the teaching of engineering students. In place of the slipshod work of graduate assistants newly recruited each year for a distasteful task, there will be substituted efficient teaching by men specially trained to meet the problems of the engineer. Too many young men teaching technical students know little about the course material; too few are willing to learn. In senior courses centered on the writing of engineering reports and articles, the average member of an English department usually fails to understand the technical problems involved. An English faculty permanently attached to the School of Engineering would go beyond a superficial acquaintance with the subject matter.

Another advantage of the proposed type of organization is that it will result in more practical work for the student. The aesthete will be relieved from teaching in the Engineering School, and the relief will be mutual for student and teacher. Subjects for writing will grow out of the engineering work itself, with a consequent sharpening of student interest; the engineer's need for English will be apparent to him.

Because this plan will require special training for the English faculty—training as specialized as that of engineering instructors—salaries should be on the same level as those of their engineering colleagues. These salaries, in fact, should be part of the budget for the School of Engineering and should not come from funds allocated to the College of Liberal Arts. Only a well-paid English staff will produce the expected results.

If the School of Engineering is willing to provide the funds for this plan, it will be able to attract men with the

training and ability requisite for the teaching of English to engineers. Few graduate assistants will need to be used, and those few will have served an apprenticeship under competent English professors in the Engineering School. The professors themselves will be chosen because of their knowledge of technical as well as of liberal arts subjects. Training by this sort of teacher should generate enthusiasm for self-expression in engineering graduates.

For the first time the majority of students will probably look upon English as an essential part of their technical training. Taught by men sympathetic to the ideals of engineering writing, they will be stimulated to do work of high quality.

As in every change of organization, some disadvantages will naturally be apparent. An English staff chosen to serve the engineering students and giving courses aimed to satisfy practical ends might meet opposition from the students themselves, who already think that their curriculum is too full of technical courses. The right sort of teachers, however, will offer the broad training which the student needs. Such a plan as the one advocated here should turn out more literate engineers than the present system does.

There is also the possibility that this plan might emphasize the tendency to set apart the engineering student as a peculiar species, one removed from his fellows. But with the use of block sections in English, the engineer now has little contact with students specializing in other subjects. The objection, then, is hardly valid.

From the standpoint of the English faculty, there is the possibility that the School of Engineering may dominate its work. The system outlined above, however, should produce cooperation. The English staff, being part of the School of Engineering, will share its aims. There should be no basic conflict.

The question may be asked, "How will a faculty, properly sympathetic to the engineering program and its purposes, be recruited? Where are we to find men who have both an engineering and a liberal arts background?" Two answers suggest themselves. The professorial life and a good salary may attract the articulate engineer from industry, or these same rewards may influence the man trained in English to do collegiate work in basic engineering subjects before he begins his teaching career.

If the plan as outlined should make too sharp a division between the work in English in the Engineering School and that in the College of Liberal Arts, an alternate plan is suggested which should bring most of the benefits of the first plan to students and faculty. A subdivision within the Department of English could be established to serve the interests of the engineering student. A member of the English Department should be designated as the head of this subdivision, with authority to speak concerning English for engineers at meetings of department heads or conferences on engineering training.

Like the preceding plan, this form of organization would force recognition of the fact that the engineering student needs training in English different from that given to candidates for an arts degree. At the same time, the head of the subdivision, acting with the advice of his colleagues in Liberal Arts, could insure that the engineer's training would not be too narrowly practical.

One weakness might develop. Just as in the previous plan, in which there

was a danger that the Engineering School would exert too much influence over the content of English courses, so in this case the English Department of the College might force unacceptable subject matter on the faculty of the subdivision. A head who had a realistic approach to the problems of the engineering student might well overcome this disadvantage. Emphasis again should be given to the special training of the faculty constituting this subdivision. This entire plan would be unworkable, of course, if the head of the Department of English in the College were unsympathetic to the special needs of engineering students.

When these two plans are considered, it appears that the first has several advantages over the second. A separate Department of English for the School of Engineering would give its members freedom of action to work out plans in cooperation with the School of Engineering. In addition, the members would be able to confer when necessary with their colleagues attached to the English faculty of the College. The difficulties of setting up a department within a department would be avoided. The student would have the advantage of being taught by men who have specialized in engineering communications; he would be assigned more practical and interesting work. Either plan, however, would be more effective than our present inchoate system.

Modifications and Trends in Engineering Curricula*

By W. G. VAN NOTE

Director and Head; Department of Engineering Research, North Carolina State College

A little over a year ago Dr. Benjamin Fine, educational editor of the New York "Times," stated that "Nearly every institution of higher learning has one or more curriculum committees working on the problem of preparing plans to meet changing conditions of a world at peace." The accuracy of this statement has been amply substantiated by the frequency with which announcements have been released by colleges concerning their adoption of new curricula following committee reports.

Like so many other faculties during the past several years, those of the North Carolina State College have been engaged in extensive studies to formulate post-war plans. It was my interesting fortune to be active in the Planning Committee of our School of Engineering, which after more than a year and a half of study and deliberation made recommendations concerning post-war engineering curricula. During our work an appreciation was gained of the history of the development of engineering education to its present state of youthful maturity. My remarks here are a result of the impressions gained during the life of our committee.

It seems proper that engineering curricula be continuously under scrutiny and subject to periodic re-evaluation. This is essential, first in the effort to assure that adopted curricula are adequate for current times, and second that curricula revisions be made in keeping with the changes in our society and technology that inevitably occur with the passage of time.

To say that times change is admittedly trite, but a striking, as well as an amusing, example of this truism was noted when we ran across the following rules from an American school as published in 1784.

"We prohibit play in the strongest terms . . . the student shall rise at five o'clock in the morning, summer and winter, . . . the student shall be indulged in nothing that the world calls play. Let this rule be observed with strictest nicety; for those who play when they are young will play when they are old."

I wonder how many of you were on the golf course at some time during the past week or anticipate a foursome in the days directly ahead. It is doubtful if a sharper contrast can be found between former and current educational philosophies than this one just quoted.

The many institutions that have had committees busy with curricular studies these last few years include

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both general and specialized colleges and schools. Among the general colleges, the Harvard Report, "General Education in a Free Society," has probably received the most widespread publicity. Shortly after this was made public, similar committee activity was reported from Princeton and Yale. In each recommendation, a common trend is noted. This is in the turning away from the free elective system which was introduced by President Elliott of Harvard more than sixty years ago and was accepted generally by most liberal arts colleges in succeeding years. While in the present recommendations elective privileges will be curtailed to prevent random choice, students will not be held rigidly to a fully prescribed program but will have limited electives from a group of integrated studies. Reports from many other schools indicate trends generally similar to those reported by Harvard, Yale, and Princeton.

Turning to a review of the picture in engineering education, it is profitable first to trace briefly its development.

Until about a century and a quarter ago, engineers prepared for their work quite as they had done through the fifty preceding centuries. It appears that there was much in common between the engineering training of those who built the pyramids and the ancient roads and aqueducts of Rome and those who built the Erie Canal. Both were taught by observation, practice, and apprenticeship.

However, in the middle of the 18th Century, schools for engineers were begun in Europe. The first of these were primarily for the training of military engineers, and it was only a short step from military to civil engineering. It appears that the first of these European schools arose in France, though one authority gives convincing proof that engineering education began in Germany, and further that these schools were initially inaugurated for instruction in the field of the mineral industries.

The development of engineering education in France influenced markedly the initial tendencies of similar instruction in this country. Rensselaer Polytechnic Institute began in 1824 as the first collegiate school of engineering in any English-speaking country. Its leadership had important influence on subsequent engineering education here, and since it had in turn been influenced markedly by France's Ecole Polytechnique, this French influence was transmitted to the United States. Simultaneously with this European influence on the initial development of our engineering schools, there was the influence of our own general college. This resulted from the introduction of engineering curricula into the general colleges between 1840 and 1860. In many instances, the engineering unit was dependent upon the support of the arts college and the philosophy of the latter was impressed upon the engineering educator. There was, indeed, at that time, engineering material sufficient only for about one year's instruction. The following is from an announcement from Rensselaer early after its inception.

"Students of the engineer corps are instructed as follows: Eight weeks in learning the use of instruments (as compass, chain, scale, protractor, level, etc.) with their applications to surveying, leveling, calculating excavations; eight weeks on mechanical powers, circles, conic sections, construction of bridges,

arches, railroads, canals, running circles for railways; four weeks in calculating the quantity of water per second supplied by streams as feeders for canals or turning machinery; four weeks to study the effect of steam and wind as applied to machinery."

There was also a strong influence of military educational philosophy on early engineering education. This resulted from a goodly number of West Point graduates resigning their commissions and accepting positions in the various newly assembled engineering faculties.

As the engineering curricula and faculties grew within the general colleges, there was inevitable conflict between the two groups, in method and viewpoint. It was not an easy time in the growth and development of engineering curricula.

A great stimulus to engineering education development occurred in 1862 in the passage of the Morrill Act, which created the great system of land-grant colleges and universities throughout the country. This Act gave general recognition to education in agriculture and the mechanical arts and insured the establishment of at least one institution directed to this aim in every state and territory. This led to a rapid expansion in the field of engineering education.

Another growth factor in the development and general public acceptance of engineering education was reached at the Centennial Exposition of 1876. There for the first time the public saw exhibits which included the Corliss engine, gas lights, and the electric generator and motor.

This public interest resulted in rapid technological strides, and by the time of the Columbian Exposition in 1893, engineering education and educators had attained a stature and a professional consciousness of such proportions that engineering education seemed now well able to stand without assistance from the general college. As a result of this, separate curricula, now quite divorced from the general college, were developed. As science and invention marched on, new machines and technologies were introduced, and there was great pressure to include instruction in these new fields in the engineering curricula. This was done at the expense of the social and humanistic courses, which earlier were there through the influence of the general college. It is also quite probable that this exclusion of these courses was furthered because of the lack of sympathy for them on the part of the engineering faculty, which had resulted from earlier clashes with the arts faculty and administration.

Feeling their professional consciousness and sensing their contribution to industrial progress, the engineering educators formed in 1893 the Society for Promotion of Engineering Education, now The American Society for Engineering Education. As you so well know, this Society continuously grew and has made itself felt tremendously in the general development of engineering education. From the turn of the century up to the time of the first World War, those responsible for engineering curricula probably felt their maximum freedom from the necessity of association with the social and humanistic influence. However, World War I began to awaken within the engineer a realization of the part he plays in the development of the culture as well as the civilization in which he lives. There were distressing results of embarrassment and humiliation from this appreciation.

The engineer began to realize that while he contributed markedly to the industrial development of his time, he had little understanding and less control over the social problems posed by the very industrial development he sponsored. References in our journals are legion concerning this gradual awakening among engineers to the fact that all was not ideal within the engineering curricula of the 20th Century. Repeatedly, engineers were referred to as the servants, not masters, of industry, the contributors to a technology, but seldom the leaders of a society.

There were those who felt that an engineering training was adequate to qualify one for successful participation in social and economic affairs without benefit of courses in the so-called "humanities." Yet by and large, this conclusion seems false. Professor Straub of the University of Minnesota spoke at a civil engineering educational symposium in 1941 on this question, and I quote him:

> "I cannot agree that our much glorified 'engineering approach to a problem' is the panacea which the world has been awaiting. In fact, the technical procedures of the engineer, where not tempered by the perspective gained in studies in the humanities, definitely handicap him in his efforts to unravel social problems. He fails to recognize that the structure of social-economic order is dynamic and constantly changing—fundamentally different from technology. The ever-changing problems of human affairs do not lend themselves to fixed formulas as technology does, encompassed as it is by the rigid laws of the physical sciences."

There was also an increasing awareness of the change in our country, in the limits to further geographic expansion and a consequent re-definition of areas of possible service.

Dean Hudelson of the University of Illinois has pointed out that in that State whereas in 1870 there was an agrarian isolation with only 17 per cent of the population living in towns of 8,000 or more, there is now the industrial congestion resulting in 74 per cent of the people living in towns of more than 10,000.

Another trend of tremendous influence has developed since the formation of the A.S.E.E. This is the growth and popularization of higher education in general. It was more of a distinction to graduate from high school in the year of the founding of our Society than it is to graduate from a college today. Since 1893, there has also been a moderate expansion in a number and variety of engineering curricula.

It was inevitable that many pressing problems develop from the tremendous expansion of engineering education within the last fifty years. One of the most prominent and perplexing has been the inevitable crowding of a curricula limited to four years, and many have been the attempts to solve the problem this poses. Recognizing that no true solution was evolving, this problem led in 1939 to the formation within the S.P.E.E. of a committee on the Aims and Scope of Engineering Curricula under the chairmanship of H. P. Hammond of the Pennsylvania State College. The report of that committee has been widely studied and has had great influence on the trend of engineering education up to today.

Early in its deliberation, this committee noted that engineering is a functional branch of our national system of higher education, being the

technology branch in contrast to that of agriculture, economics, etc. Thus, it is not comparable to the professional schools such as Law, Medicine, and Theology. So we find that the engineering curricula have the responsibility for the full and broad education of those students choosing engineering as a career.

This must include responsibility for social and humanistic instructions as well as for it in science and engineering. The professional schools which can demand a preliminary college period of study such as pre-law, premedicine, are freed from such requirements. Thus, we begin to sense the responsibility of the engineering faculty.

For at least the past two decades, various engineering educational leaders have recommended that, as a solution to this very real dilemma, curricula leading to the Bachelor's degree in engineering be lengthened from four to five years. But it is financially and economically difficult on both school and student, particularly the latter, to lengthen the four-year course that has for so long been the norm. A number of schools have experimented with this proposal, but it has never been generally accepted. Such five-year trials as were in operation at the beginning of our entry in World War II were nearly all abandoned due to the pressure of urgent war programs. Now with the post-war policies developing one can expect with assurance that this manner of solution will be tried again. Today we find Minnesota, Ohio State, and Cornell announcing the adoption for five-year curricula in engineering with no shorter alternative offered, at least to non-veterans. The engineering educational world will watch with keen interest the response to the five-year curricula ventures of these leading engineering schools.

World War II has, of course, tremendously underscored the need for the training in citizenship, social responsibility and leadership along with the technological training for all engineers. Adequate attention to social-humanistic needs must be given.

Training in English to insure that young engineering graduates have the ability to express themselves in a clear, concise manner is being demanded with increasing emphasis. The advances in special technologies have been so varied, rapid, and extensive that coverage of special technologies is now impossible. These advances, further, require sound fundamental knowledge for their understanding and successful study in later years, either in post-graduate work or in industrial practice. Because of these urgencies in varied fields of general education, the philosophy underlying engineering education is today being based more and more on a broadening of the base of engineering education in which strong emphasis is placed on fundamentals, rigorous instruction in the use of English, and inclusion of a well-planned social-humanistic stem.

Since these bases are common to the needs of all engineering curricula, it has been possible in many instances to create a curriculum that is uniform for all engineering students for the first year. As the desirability for the universality of basic instruction in all engineering curricula has increased, it has been possible to extend this curricular uniformity well into the second and even to an appreciable extent into the third year. Beyond the philosophical justification for this trend, it further offers practical advantages to both student and faculty. It allows the

student a longer period of engineering acquaintanceship prior to his making his vocational choice, and through simplification of instruction it eases the administrative burden of the faculty. While I cannot at the moment accept the extent to which I have recently heard this trend proposed, I have found in several widely separated instances the suggestion that out of a four-year program leading to the Bachelor's degree in a designated engineering branch the first three years be totally uniform.

Because of the impact of World War II, the report of the Committee on Aims and Scope of Engineering Curricula was re-submitted for study to a committee on Engineering Education after the War, appointed in 1943. This was also under the chairmanship of H. P. Hammond. This committee was "directed specifically to study the need, as made clear by the issues of war, of creating among engineers an understanding of the social and economic world they live in and have so large a share in creating."

This committee re-substantiated the report of the earlier committee on Aims and Scope adding to it special emphasis on social responsibility and suggesting that undergraduate engineering training should be developed for three groups of students: (1) those who would follow engineering programs for the usual pattern, (2) those preparing for jobs in the operation and management of industries, and (3) those who would be fitted for unusual scientific and creative accomplishments. The committee report gives detailed suggestions concerning means for achieving these educational objectives. It was this report that recommended not less than 20 per cent of the student's educational time be devoted to the humanistic-social stem.

A second problem that resulted from the tremendous growth in higher education since 1893 has been the large numbers of students seeking a four-year engineering education who might better be served by a short program that prepares men with the practical techniques of particular occupations or industries. This leads to the urgent need, as yet almost totally unmet in the United States, for Technical Institutes. It is noted that in Great Britain, in the Soviet Union, and in pro-war Germany such a program was carried out on a far greater scale than anything yet developed here. In the U.S.S.R. in 1938 it was reported that there were 3,400 technical institutions with an enrollment of 700,000 students. It is most desirable that the engineering colleges take a leading part in the development and guidance of this form of institution during its rise. Time does not permit me to elaborate this need further, but it is among the most pressing now facing engineering educators, and it will continue to receive increasing attention. The growth of this form of technical instruction is one development in the general field of engineering education that can be predicted with certainty.

One major function, essential to engineering education, has yet been unmentioned. Dean Hammond, while reviewing the past in engineering education at the time of the 50th anniversary of the founding of the S.P.E.E., said, "In engineering research, the record of development of the past fifty years had not, on the whole, been as satisfactory as it has in instruction. There has never been accorded to research in engineering in this country anything approaching the support

which has been accorded to research in agriculture; nor has engineering research in educational institutions approached in magnitude or importance similar research in industry. Most of the research that has been done has been confined to a score of institutes. This one great phase of the work of engineering educational institutions which should complement other phases, needs greatly to be strengthened and supported." Speaking on the same program, President Karl Compton of M.I.T. said, "Our engineering education has not been as productive in developing the research side as it has in developing the side of the practical application of the most conventional arts. . . . I don't know how important this research side is to the engineer, but it is very important to society that attention be given it. If it is not given by the engineer, it will be given by other groups; it will be given always by scientists."

The growth of research in engineering institutions is essential to the further effectiveness and maturity of engineering education. The programs of research in engineering schools must be integrated with the educational program and is recommended in the report of the committee on Engineering Education after the War, particularly for those students who plan to undertake graduate work.

In reviewing current trends in engineering education, several other items are prominent. I can only quickly enumerate them here. One is the increase in the attention to individuals or small groups. Tendencies in this direction are noted with increasing frequency. There will also be an increase in part-time graduate work by young graduate engineers' who are in industry and who attend colleges located in industrial centers. Those schools not favorably located in relation to industries will match this by increasing numbers of industrial fellowships and research programs closely allied with industrial problems.

Turning for a moment to the social-humanistic stem, the conclusion seems that it should be taught as a parallel development with the science and engineering sequence rather than departmentalized without relationship to its associate studies, or given solely during the earlier and more immature years of student study.

One trend which appears now, being greatly accelerated by war research experience and one which I believe will be sharply developed, is the lessening of sharp administrative divisions that departmentalize faculties. There will be an increasing interrelationship between department faculties where, for example, a physics professor will teach in electrical and chemical engineering; a thermodynamist will cut across department lines by teaching in mechanical and chemical engineering and in physics. Many other possible examples can be quickly visualized. Such a program has been in effect with considerable success for many years in the organization of Columbia College's course in Contemporary Civilization. Recently M.I.T. announced a new method of research technique in terms of groups wherein men from various departments, for example a metallurgist, a physicist, and a physical-chemist from their respective departments, join with a group of chemical engineers to undertake more effectively work on research problems. Such associations will of necessity be loosely formed, dissolving and reforming new associations as needs arise. I feel confident similar groups will de-

velop in our teaching methods and produce greater teaching effectiveness.

Lastly, I would say a few words concerning recommendations of the Planning Committee of the Engineering School of the North Carolina State College.

Because of economic factors, we do not favor the extension of those curricula leading to the Bachelor's degree from four to five years. Four-year curricula in basic engineering divisions leading to the degree of Bachelor of Designated Engineering are to be retained.

Thorough training in English composition is to be given. The efficiency of this training shall be determined by an achievement test given to the student at the end of the junior year. Those showing need for additional instruction shall be given this during the senior year.

Emphasis is to be given to fundamental knowledge and total hour requirements, in terms of quarter hours, have been lessened from an average of 240 to 225 to permit the added time required by this phase of the program.

Forty-two hours are to be devoted to a newly organized social-humanistic stem. This will include in the Freshman year nine hours of Composition and a second nine hours devoted to studies on the Rise of Western Civilization. This latter gamut will serve as an introduction to the remaining twenty-four hours of the stem that are to be given in the subsequent three years. Parallel development with our science-technology stem is insured by spacing these hours evenly throughout the upper three years. These hours shall be devoted to an election of not fewer than two nor more that three fields chosen from the following: Literature, Economics, History and Government, Ethics and Philosophy, and Sociology. Limited individuality in course program is permitted through eighteen hours of additional electives in the upper two years.

Opportunity for advanced study is recommended through two types of graduate programs, each of one year's length and each leading to a Master's degree. One, leading to the Master of Science degree, is developed with a strong emphasis on research and is offered primarily to those who wish to enter this type of life work and who may wish to continue through the Doctorate. The second is a Master of Specified Engineering program that is considered terminal and requires less research but gives greater emphasis on course work. This program is designed for men wishing to enter industry.

The research activity of the engineering school is being stimulated through the Department of Engineering Research, which has been created by a reorganization of the former Engineering Experiment Station. It is the function of the Department to assist and encourage faculty members with their research interests by offering them opportunities of association with problems brought to the school by outside agencies. These agencies may be state or federal government units, technical or industrial associations, or private companies or individuals. Integration between research problems and student instruction is realized by having student participation in these problems, either through fellowships or by hourly wage agreements. The Department also provides assistance to those faculty members who wish to engage in fundamental research for which no outside support is available.

We appreciate that we have not solved all problems. Further, we know that some of our decisions, which to us appear as successful solutions, would not be of equal use to others because of differences in situations or state needs. Yet we feel that we have stepped forward. We look to those about us who are engaged in similar endeavors and from you we hope to learn further and trust that we may, in turn, be of some value to those of you who look to us. We believe we are together trying to aid and be aided in our unending task of the furtherance of engineering education. We have confidence in our collective ability to meet the challenges of the day.

Southeastern Section, A.S.E.E.

The Speed Scientific School of the University of Louisville was host to the Southeastern Section of A.S.E.E. and the Research Branch of the Section at their thirteenth annual meeting on April 17–18–19, 1947. Nineteen of the twenty-two colleges in the Section and three industrial organizations were represented by the ninety members attending.

The meeting of the Research Division was held on April 17. Reports from all the colleges in the Section showed a surprising increase in research activities since the research branch was begun in 1944. All of the colleges reported plans for still further increases for the coming year.

Harry Diamond spoke on "Miniaturization of Electronic Circuits." Great advances had been made in research on this project, he said, by the miniaturization of electronic tubes and by painting the circuit on a plastic background.

The theme of the first meeting of the Section on the morning of April 18 was, Getting Back to Normalcy.

R. R. Slaymaker described the method of limiting enrollment at the Case School of Applied Science by the use of the Pre-Engineering Inventory tests used in combination with special tests prepared at the Case School. Through the use of these tests, he said, the number of failures have been decreased to one per cent.

James L. McAuliffe of the University of Tennessee spoke on The Influence and Progress of the War Veteran on the Campus. His talk was based on his experience with the veterans on the campus at the University of Tennessee where he found that the veterans, after being on the campus for one term, were a highly vocal and progressive group and in general had a sobering influence on the campus. They were more sensitive to opportunities, carried on better discussion in classes and increased the social activities of the campus on a lower cost level. Dr. McAuliffe said that he felt that in many ways the veteran was a definite contribution to campus life. He pointed out, however, that, judging from the veterans, the army was a poor place for physical development or education.

In talking to the section on the subject, Modification and Trends in Engineering Curricula, William G. Van Note of N. C. State College gave a brief resume of the history of the development of the engineering curricula in the United States. The present trends he said were as follows:

(1) Tendency to make the first three years of the five curricula uniform.

(2) An increase of above 20 per cent of Social Humanistic items in all curricula.

(3) Building up interest in Engineering Research which at present is not so great as industrial research.

(4) Tendency toward greater specialization especially in graduate curricula.

R. D. Span, of the Alabama Polytechnic Institute, speaking from his own experience on the Values of Humanistic Social Courses in Engineering Curricula, said that something should be done to get the student out of the deep valley of not understanding human beings around him. The Humanistic courses, he felt, should be planned to take hold of the mind of the student as a part of his engineering course. The courses should be given in the early part of his course so they would be of advantage to him in dealing with other students and the instructors in the advanced work.

The theme of the afternoon session was, Keeping Pace with the Times. The principal speaker for this session was Harry Diamond who spoke on The Status of Engineering Research in Electronics.

Dr. Diamond pointed out that the oversold public, the lack of trained personnel and the retarded rate of progress in pure science were problems beyond the control of the research engineer.

Points brought out in his paper were as follows:

1. The emphasis on engineering research during the war has advanced our knowledge of materials, design technique and instrumentation.
2. There is no lack of fundamental principles on which to base engineering research.
3. There is much need for accelerated research to meet the demands of society. This can be supplied by redoubling our present efforts.
4. We must rely in a great measure on the pure scientist to bridge the gap between fundamental knowledge and engineering application.

W. G. Ireson of Virginia Polytechnic Institute spoke on The Improvement of Class Room Instruction. He believes class room instruction is influenced by four factors: the teacher, the student, the facilities and the subject. A teacher, he said, should be selected on the basis of his personality, ability to express himself well, and his knowledge of the subject to be taught. Too often we select the teacher who has great knowledge of the subject but who cannot impart the knowledge because of a lack of personality or self expression. Too many students, he said, are enrolled in engineering schools who are not properly equipped to do the work. We must be more careful in the selection of our students. The use of class room aids not only helps the student but saves the teacher time in getting the subject across. Finally, he pointed out, that in teaching any subject it is necessary to correlate that subject to other subjects taken by the student and to the student's background knowledge.

Frank G. Slack of Vanderbilt University, speaking on Atomic Energy and the Atomic Age, pointed out that there should be a greater interest shown by the colleges in the work of the Atomic Energy Commission by sending representatives of their faculty to take the courses of study offered at the Atomic Energy plants. Research in Atomic Energy, he said, was growing by leaps and bounds and that now the new found elements and the radio active isotopes were being extensively used in many fields of science and medicine.

Henry N. Lyons, Administrative Manager of Laboratories for the Devoe Reynolds Co. of Louisville, spoke on Shortcomings of the Present Graduates as Diagnosed by an Industrialist. The

recent graduates, he said, have received adequate training in the fundamentals of the engineering course they elected in college but they generally lack a practical working knowledge of mathematics and an appreciation of the importance of a knowledge of fundamental business principles. He considered mathematics, especially calculus and differential equations, a most valuable tool in the hands of the engineer. The colleges, he believes, should do something about this mathematical shortcoming. In the matter of the lack of knowledge of business, he said, there is little the engineering college can do in a crowded four year curriculum other than to stimulate interest in the subject by short courses.

W. N. Cox, of Georgia School of Technology, speaking on Safety Engineering in Engineering Curricula, described the course as offered at the Georgia School of Technology and stated that he thought there was a need and a place for safety engineering courses in all engineering curricula and especially in those related closely to industry.

A forum on the subject, Teacher Shortages, was held at the last session on the morning of April 19th with four speakers participating,

R. O. Shots of the University of Alabama gave the historical background of the causes of teacher shortages.

I. A. Trively, speaking on Industrial Opportunities Vs. Those of Teaching, pointed out that we could not hope to attract the good men from industry until we gave them adequate pay and adequate facilities with which to work.

R. E. Shaver, speaking on Effects on Staff Morale, said that he believed that the quality of man now in the engineering colleges would turn in a good job in spite of an overload. Since this is a temporary condition we should be glad to carry on since we now have the kind of students we have all been waiting for.

O. W. Stephenson of Tulane University, speaking on Some Avenues of Hope, said that the teacher shortage had taught us several things. One was the fact that we needed more laboratory equipment so that the student could do more work by himself. In this way one teacher could handle more men in the laboratory. This could be carried into the class room too. With better instructional aids one instructor could teach more students at one time.

At the conclusion of this final session a short business meeting was held. It was decided that the meeting for the spring of 1948 would be held in Gainesville, Florida, the University of Florida as host institution. Appropriate resolutions were passed thanking the Speed Scientific School for their wonderful hospitality.

The following officers were elected for the next year.

Chairman: Fred J. Lewis of Vanderbilt University.

Vice-Chairman: J. E. Hannum of Alabama Polytechnic Institute.

Member of Council: Leo. Jos. Lassalle of Louisiana State University.

Secretary: H. Gale Haynes, The Citadel.

Second International Conference on Soil Mechanics and Foundation Engineering

The Second International Conference on Soil Mechanics and Foundation Engineering will be held in Rotterdam, Holland, in June 1948. This meeting, sponsored by the Netherlands Government, is a resumption of the series initiated at Harvard University in 1936 and interrupted by the war. The president of the Conference is Karl Terzaghi, Consulting Engineer and Professor of Engineering Practice at Harvard University. The Conference is being organized by J. P. Van Bruggen, Director of Public Works, Rotterdam, T. K. Huizinga, Director of the Laboratory of Soil Mechanics in Delft, and other Dutch engineers. The Conference will be conducted in the English language.

In the United States, a National Committee on Soil Mechanics, consisting of thirty-five outstanding foundation engineers and soil mechanics experts representing professional engineering societies and governmental engineering organizations, has been formed. Philip C. Rutledge, Professor of Civil Engineering at Northwestern University, is chairman of the Committee. Its official address is: U. S. National Committee on Soil Mechanics, the Technological Institute, Northwestern University, Evanston, Illinois. To insure adequate representation of the United States in the technical works of the Conference, the National Committee has been divided into fifteen subcommittees covering the major technical subdivisions of Soil Mechanics and Foundation Engineering.

Prospective members of the Conference and authors of papers are requested to notify the National Committee of their intentions as soon as possible. To meet the conditions set up by the Dutch organizing committee, authors of papers to be published in the first volume of Proceedings of the Conference must submit in triplicate to the National Committee a title and brief (250 word) description of each paper prior to September 1, 1947. For this volume completed papers must be received by the National Committee by December 1, 1947.

Organized travel for those attending the Conference is planned and will be arranged by the National Committee. Complete information on the Conference can be obtained by writing to the U. S. National Committee on Soil Mechanics.

Publication of a new "Directory of Member Institutions and Review of Current Research" was announced by the Engineering College Research Council of the A.S.E.E. at the Annual Meeting in Minneapolis, where first copies of the new bulletin were distributed.

The major publications activity of the Research Council last spring, the new Directory lists the directors and research officers, gives a brief statement of research policies, personnel, and expenditures, and lists research projects now active in various divisions of each member institution.

An extensive free distribution of the Directory has just been completed by the Research Council, including a large number of federal and industrial research laboratories. Libraries of all member institutions of the Research Council have received copies. While the supply lasts, additional copies are available at $1.00 each from the Secretary of the Research Council, John I. Mattill, The State University of Iowa, Iowa City, Iowa.

College Notes

Douglas F. Miner has been appointed Director of the Division of Student Personnel and Welfare at the **Carnegie Institute of Technology.** In accepting his new appointment, Dr. Miner has resigned as George Westinghouse Professor of Engineering, a post which he has held since September 1938.

Case Institute of Technology (formerly Case School of Applied Science). T. Keith Glennan, now an executive of Ansco Division of General Aniline & Film Corporation, Binghampton, N. Y., and wartime director of the U. S. Navy Underwater Sound Laboratory, has been appointed president of Case Institute of Technology.

Mr. Glennan will be the first business executive to head the Cleveland engineering school, which has had but three presidents since its establishment 67 years ago as Case School of Applied Science and which is adopting its new name on July 1st. He succeeds Dr. William E. Wickenden * who retires on September 1st, after 18 years of service.

The **Texas A. & M. Research Foundation** formally inaugurated service of the newest alternating current network calculator laboratory at College Station, Texas, on June 27, although the first study was actually begun on June 2. Leading engineers of the several companies who cooperated in establishing this laboratory were present to inspect the calculator and review preliminary plans for their respective studies.

* Died September 1, 1947.

Manufactured by the Westinghouse Electric Corporation, the Texas A. & M. calculator has a total of 18 generating units and 344 circuits, and is one of the largest ever constructed. It is the first to include several unique features such as pi-circuits to represent long transmission lines, and an auxiliary potential that may be used as a reference voltage on the instruments. The calculator is also equipped with two master control and instrument desks with the circuits so arranged that it will be possible to study two systems simultaneously. The use of the second control desk will permit instruction of and research by graduate students without interfering with studies by utility companies.

A-c network calculators have, for the most part, been used by electric utility companies in the study of load flows, short circuit analysis, stability problems, etc. Since all other physical systems, e.g., mechanical and hydraulic, have electrical analogies, the use of a network calculator is not limited entirely to electrical systems. The Texas A. & M. Research Foundation also plans to add accessory equipment which will extend use of this calculator to the study of traveling wave transients and other phenomena.†

† "The Network Calculator Brought Up to Date," H. A. Travers, *Westinghouse Engineer,* July, 1944.

"Today's Network Calculators Will Plan Tomorrow's Systems," Dan Braymer, *Electrical World,* January 5, 1946.

"Mechanical Problems Solved Electrically," G. D. McCann & H. E. Criner, *Westinghouse Engineer,* March, 1946.

The Texas A. & M. network calculator is installed in Bolton Hall, the Electrical Engineering Building, on the campus of the Agricultural and Mechanical College of Texas. The Research Foundation is a non-profit corporation organized so as to use the facilities of the College in research that will contribute to state and national development. The calculator laboratory is under the direct supervision of Lewis M. Haupt, Professor of Electrical Engineering, with R. D. Chenoweth assisting. Both have had previous experience on the Westinghouse network calculator at East Pittsburgh, Pennsylvania.

The companies who cooperated in establishing this laboratory are: Central Power and Light Company, Community Public Service Company, Dallas Power and Light Company, El Paso Electric Comany, Gulf States Utilities Company, Lower Colorado River Authority, Southwestern Gas and Electric Company, Texas Electric Service Company, Texas Power and Light Company, West Texas Utilities Company, and Westinghouse Electric Corporation.

Sections and Branches

University of Colorado Branch. Members of the University of Colorado Branch held a meeting in January to elect new officers. This was the first meeting since the University went on a war-time basis. Succeeding W. Otto Birk, as Chairman, and W. S. Nyland, as Secretary, are Arthur J. McNair and William Brubaker. Professor Birk still remains the chairman of the Rocky Mountain division, and he is arranging a meeting of the Sections in Wyoming and Colorado to be held in Boulder sometime in April.

A second meeting of the Colorado section was held on March 2, with the N.R.O.T.C. officers in charge of the program. Captain C. A. Fine gave a talk on the history of aviation, illustrated with several movies.

The 11th annual meeting of the **Pacific Northwest Section** was held at the State College of Washington on May 9 and 10, 1947.

Friday afternoon was used for registration, inspection of the State College of Washington's laboratories and getting acquainted.

At 7:00 P.M., the annual banquet was held in the Home Economics Building. After the usual good dinner, W. A. Pearl, acting as toastmaster, introduced Dean Royal Sloan, who welcomed the guests to the State College of Washington and to Pullman. Following the welcoming, talks were given by E. R. Wilcox of the University of Washington, and F. W. Candee of the State College of Washington on their experiences at Shrivenham and Biarritz, Both had interesting reports of their activities at those schools in our first effort at "G.I." education. Ending the formal program on a lighter vein, Scotty Aplchall, a magician of Pullman, entertained with a magic act. A long period of visiting and getting acquainted followed.

The Saturday morning technical meeting was called to order by Chairman Candee, who introduced Homer J. Dana, who presided over the morning session. Due to his efficient handling,

the meeting moved at good speed. The topic for the first meeting was "Post War Engineering Education—Present Problems and Future Plans." Talks were given by representatives of each school and many interesting and revealing points were brought out by each speaker. The discussion following showed that a great deal of interest had been aroused in the audience. Talks were given by:

G. W. Gleeson, Oregon State College.
B. T. McMinn, University of Washington.
W. W. Tinniswood, University of Idaho.
C. A. Arents, Montana State College.
S. P. Spielman, Montana School of Mines.
J. G. McGivern, Gonzaga University.
S. T. Stephenson, Washington State.

After a brief intermission, a paper was given by W. A. Pearl, recently appointed Director of the Institute of Technology of Washington State College, on the subject "The Cooperative System in Engineering Education." Dr. Pearl spoke from his experiences in helping set up such a system at Illinois Institute of Technology. Again the discussion following showed the interest of the audience, particularly in the possibilities of cooperative systems in northwest schools.

Oregon State College presented an invitation to hold the 1948 convention at Corvallis, Oregon, and the invitation was accepted. Following the usual custom, the officers for the coming year are all from Oregon State College and are:

Chairman, A. L. Albert,
Vice Chairman, W. H. Paul,
Secretary-Treasurer, M. P. Coopey.

After lunch at the Home Economics dining room, the afternoon session opened with a report on the 1946 Surveying Conference by F. W. Welch of Washington State College. He told of the history of the conferences and invited everyone interested to attend the 1947 conference to be held at Washington State's Summer Surveying Camp in the Snoqualmie National Forest near Naches, Washington.

Following Mr. Welch's report the meeting broke up into departmental meetings for discussion of individual department problems. Sessions were held for:

Mechanical Engineering—D. E. Aldrich, Chairman.
Electrical Engineering—O. E. Osburn, Chairman.
Civil Engineering—L. B. Almy, Chairman.
General and Administration—R. D. Sloan, Chairman.

Respectfully submitted,

L. B. ALMY,
Secretary-Treasurer

The annual meeting of the **Rocky Mountain Section** was held at the University of Colorado on Saturday, May 10 1947. The conference was held in the Engineering Administration building, with all schools of the section represented—University of Wyoming, University of Denver, Colorado A. & M. College, Colorado School of Mines, and the University of Colorado. Over one hundred members and guests attended the sessions. The program, which was arranged by Professor Arthur J. McNair, chairman of the host branch, was as follows:

10:00 A.M. Morning Session:
Call to order by Arthur J. McNair, Secretary.
Greeting from Dean C. L. Eckel, College of Engineering, University of Colorado.

A Word of Welcome—Robert L. Stearns, President, University of Colorado.

10:30 A.M. "The Aim and Scope of a General Economics Course for Engineers" by James E. Dugan, Assistant Professor of Economics, University of Colorado.

Discussion.

11:15 A.M. Dean N. A. Christensen, College of Engineering, Colorado A. & M. College, Presiding.

"The Electrical Engineering Curriculum" by V. O. Long, Associate Professor of Electrical Engineering, University of Wyoming.

Discussion by Fred H. McClain, Professor and Chairman of Electrical Engineering, University of Denver.

Afternoon Session

2:30 P.M. Dean R. D. Goodrich, College of Engineering, University of Wyoming, Presiding.

"Laying a Professional Foundation in the Freshman Year" by Robert L. Lewis, Professor and Head of Department, and Robert H. Dodds, Associate Professor of Civil Engineering, Colorado A. & M. College.

Discussion.

3:15 P.M. Dean C. M. Knudson, College of Engineering, University of Denver, Presiding.

"The Relation of Laboratory Investigational Problems to Field Applications" by George W. LeMaire, Assistant Professor of Petroleum Refining Engineering, Colorado School of Mines.

Discussion.

3:40 P.M. "Chemistry in the Mineral Industries" by Robert A. Baxter, Associate Professor of Chemistry and of Fuel and Gas Engineering, Colorado School of Mines.

Discussion.

After a noon luncheon meeting, the members and their guests made a tour of the various laboratories, shops, and classrooms, which were open for inspection. The tour was followed by a business meeting. As the Section had not met since 1942, considerable reorganization was required. Professor J. T. Strate was elected chairman and Professor Robert H. Dodds secretary for the year 1947–48. The Section gladly accepted the invitation of the Colorado A. & M. College to meet at Fort Collins next year.

The following resolution was presented and accepted by the Section:

"Be it resolved: that the Presiding Chairman request the members of the Rocky Mountain Section, American Society for Engineering Education, in annual meeting assembled May 10, 1947, to rise and stand for a moment in silent memory of:

John C. Fitterer (of School of Mines)
Allan S. McMaster (of University of Colorado)

whose fellowship and friendly counsel in this group we find sorely missing. Be it further resolved: that the Secretary of the Section be instructed to prepare a notification of this action and transmit it to the surviving next-of-kin of these gentlemen."

In conjunction with the A.S.E.E. meetings, the student chapters of the American Society of Civil Engineers from the foregoing schools held their regional conference, the first since 1942. Thus an opportunity was given for many of the students and faculty

to travel to Boulder together and become better acquainted. At the close of the A.S.E.E. conference, members of the Civil Engineering faculties of the various schools joined the students in a beefsteak fry on Flagstaff Mountain.

ARTHUR J. MCNAIR,
Secretary

Mineral Technology

RESOLUTION

WHEREAS, God in His infinite wisdom has taken away Thomas Thornton Read, former Vinton Professor of Mining Engineering at Columbia University, and a faithful and devoted member and former officer of the Mineral Engineering Division of the American Society for Engineering Education, and

WHEREAS, he was the leading and most active exponent of the importance of engineering training for the mineral industries, as was evidenced not only by his effective teaching and personal relationships with his students, but also by his prolific writings which included: "Careers in the Mineral Industries," "Our Mineral Civilization," and "The Development of Mineral Industry Engineering Education in the United States,"

NOW WE, the officers and members of the Mineral Engineering Division of the American Society for Engineering Education, assembled in the annual meeting of the Division at Minneapolis, Minnesota,

By these Resolutions, do express our sadness at the passing of our distinguished co-worker and beloved friend, and

We direct that a copy of these resolutions be sent to the bereaved family and spread in the Minutes of the Division.

Minneapolis, Minnesota
June 20, 1947

MEMBERS ELECTED AT JUNE 1947 MEETING

ALLEN, GEORGE H., Instructor in Graphics, Massachusetts Institute of Technology, Cambridge, Mass. J. T. Rule, D. P. Adams.

ALLEN, STUART C., Assistant Professor of Engineering Drawing, Champlain College, Plattsburgh, N. Y.

AMES, ALFRED C., Assistant Professor of English, Illinois Institute of Technology, Chicago, Ill. J. C. Peebles, W. C. Krathwohl.

AMRINE, HAROLD T., Assistant Professor of Industrial Engineering, Purdue University, Lafayette, Ind.

ANDERSON, ALVIN G., Instructor in Civil Engineering, University of Minnesota, Minneapolis, Minn. L. F. Boon, A. S. Cutler.

AXTELL, OLIVER, Instructor in Chemical Engineering, University of Maine, Orono, Maine.

BABCOCK, HENRY A., Instructor in Civil Engineering, Colorado School of Mines, Golden, Colorado.

BACHRACH, WILLIAM, Director of Education, Chicago Technical College, Chicago, Ill.

BAKER, JOHN L., Assistant Professor of Mathematics, University of Cincinnati, Cincinnati, Ohio.

BAKER, OLLIE J., Director, Low-Cost Housing Research, Louisiana State University, Baton Rouge, La.

BAZANT, ZDENEK, Associate Professor of Civil Engineering, Technical University of Prague, Prahall, Karlovonam, 1F, Czechoslovakia.

BERGELIN, OLAF P., Associate Professor of Chemical Engineering, University of Delaware, Newark, Del.

BISHOP, MYRON C., Associate Professor of Engineering, Evansville College, Evansville, Ind.

BLIESNER, GUSTOV H., Assistant Professor of Physical Science, Farragut College and Technical Institute, Farragut, Idaho.

BODMAN, ELMER P., Assistant Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio.

BORRI, ROBERT, Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill.

BOYD, GILBERT W., Associate Professor of Metallurgical Engineering, Michigan College of Mining and Technology, Houghton, Mich.

BUELL, ARTHUR W., Instructor in Petroleum Production Engineering, Colorado School of Mines, Golden, Colo.

CANNON, IRVING, Dean of Pre-Engineering, Associated Colleges of Upper New York, Champlain College, Plattsburgh, N. Y.

CARLSON, C. I., Acting Chairman, General Engineering Drawing, University of Illinois, Navy Pier, Chicago, Ill.

CARROLL, FRANK T., Instructor in Mechanical Engineering, Louisiana State University, Baton Rouge, La.

CASSINIS, GINO, Directore del Politechinco di Milano, Milan, Italy.

CHASE, HOWARD W., Assistant Professor of Shop Practices, State College of Washington, Pullman, Wash.

CLARK, ANDREW G., Head, Dept. of Mathematics, Colorado A. & M. College, Ft. Collins, Colo.

CLAYBAUGH, HOWARD S., Division Engineer in the Drainage Dept., Armco Drainage and Metal Prod. Inc., 4345 Lyndale Ave. N., Minneapolis, Minn. B. J. Robertson, T. E. Murphy.

COLLINS, H. JOHN, Chadwick Professor of Civil and Municipal Engineering, University College, University of London, Gower Street, London, England.

CRAMER, PAUL, Assistant Professor of Mathematics and Engineering, Monmouth College, Monmouth, Ill.

CUMMINGS, JERRY W., Head, Department of Aerodynamics, The Aeronautical University, Chicago, Ill.

CUNNINGHAM, CHARLES A., Associate Professor of Mathematics, Youngstown College, Youngstown, Ohio.

DAVIS, ROYAL E., Instructor in Physics, University of Detroit, Detroit, Mich.

DAVIS, S. J., Dean, Kings College, Strand, W. C. 2, London, England.

DRISCOLL, GEORGE F., Instructor in Civil Engineering, University of Notre Dame, Notre Dame, Ind.

DUMKE, WALTER H., Assistant Professor of Chemistry, Colorado School of Mines, Golden, Colo.

EASTON, CLARENCE W., Assistant Professor of Pre-Engineering, Champlain College, Plattsburg, N. Y.

EUKER, ENGELUND, Director, Tekniske Hojskole of Denmark, Copenhagen, Denmark.

EYROLLES, MARC, Director, Ecole Speciale des Travaux Publics du Batiment et de l'Industrie, 61 Boulevard St. Germain, Paris, France.

FAYE-HANSEN, K. M., Rector, Institute of Technology, Trundheim, Norway.

FENN, FRED H., Professor of Engineering Mechanics, Louisiana State University, Baton Rouge, La.

FERRARA, GUIDO, Instructor in Electrical Engineering, University of Detroit, Detroit, Mich.

FINDLAY, JAMES E., Instructor in General Engineering Drawing, University of Illinois, Navy Pier, Chicago, Ill.

FOSSUM, GUILFORD O., Assistant Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D.

FURGERSON, LYNN D., Instructor in Mathematics, East Central Junior College, Decatur, Miss. D. M. McCain, H. C. Simrall.

GERSTER, JACK A., Assistant Professor of Chemical Engineering, University of Delaware, Newark, Del.

GILLETTE, EDWARD C., JR., Professor of Physics and Chemistry, U. S. Military Academy, West Point, N. Y. B. W. Bartlett, R. I. Heindein.

GOULD, GILBERT B., Instructor in Electrical Engineering, University of New Hampshire, Durham, N. H.

GREEN, ROBERT S., Assistant Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio. C. E. MacQuigg, P. N. Lehoczky.

GUESS, ROBERT H., Instructor in Physics, Electricity and Radio, Copian-Lincoln Junior College, Wesson, Miss. D. M. McCain, A. G. Holmes.

HANSEN, HOWARD J., Associate Professor of Civil Engineering, University of Florida, Gainesville, Fla.

HARDER, KEITH C., Head, Science Education, Scientific Personnel Division, Office of Naval Research, Navy Department, 4213 28th Street, Mt. Rainier, Md.

HARMON, DANIEL L., Director, Department of Physics, University of Detroit, Detroit, Mich.

HARTUNG, WALTER M., Vice-president, Director of Training, Academy of Aeronautics, LaGuardia Field, New York, N. Y.

HEBEL, IVAN L., Professor of Mathematics, Colorado School of Mines, Golden, Colo.

HERRMANN, R. R., Manager, Rate and Sales Research, Northern States Power Company, 15 South Fifth Street, Minneapolis, Minn. B. J. Robertson, T. E. Murphy.

HILL, G. T. R., Professor, University College, Gower Street, London, W.C. 1, England.

HIRSH, FRED, Assistant Research Engineer, University of Florida, Gainesville, Fla.

HOGUE, WALTER R., Assistant Professor of Civil Engineering, University of Santa Clara, Santa Clara, Calif.

HOLLADAY, DEE M., Instructor in General Engineering Drawing, University of Illinois, Navy Pier, Chicago, Ill.

HOSSIER, KARL G. N., Rektor, Chalmers University of Technology, Gotenborg (Gothenburg), Sweden.

HOWARD, J. H., Director, Business and Technical Personnel, Eastman Kodak Company, 37 Stoneham Drive, Rochester, N. Y. E. M. Billings, H. S. Gardner.

HOWE, ROBERT T., Instructor in Mathematics, University of Cincinnati, Cincinnati, Ohio.

HUMMER, J. L., Instructor in Electrical Engineering, Rhode Island State College, Kingston, R. I.

HUYDTZ, L. H. M., Professor, Technische Hogesschool, Kanalwee 26, Delft, Holland.

IHLEFELD, WILLIAM G., Professor, Head, Department of Safety Engineering and Education, University of Puerto Rico, Rio Piedras, Puerto Rico.

JOHNSON, A. E., Instructor in Graphics, Massachusetts Institute of Technology, Cambridge, Mass. J. T. Rule, D. P. Adams.

JOHNSON, HERMAN J., Instructor in Physics, University of Illinois, Navy Pier, Chicago, Ill.

JOHNSON, JUSTIN O., Instructor in Mechanical Engineering, University of Maine, Orono, Maine. H. D. Watson, W. S. Evans.

KELLY, H. HAROLD, Assistant Professor in English, University of Colorado, Boulder, Colo.

KING, IRA L., Assistant Professor of Industrial Engineering, University of Florida, Gainesville, Florida. J. Weil, N. C. Ebaugh.

KINTZER, NICHOLAS D., Dept. Head, Design Department, Academy of Aeronautics, 336 Coolidge Street, W. Hempstead, N. Y. A. Stott, K. L. Burroughs.

KOCH, REUBEN, Instructor in Mathematics, University of Cincinnati, Cincinnati, Ohio.

KUNESH, JOSEPH F., Senior Professor of Engineering, University of Hawaii, Honolulu, T. H.

LARSON, SIDNEY C., Associate Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn.

LAVES, WALTER C., Deputy Director General UNESCO, 19 Avenue Kleber, Paris, France.

LEMAIRE, GEORGE W., Assistant Professor of Petroleum Refining, Colorado School of Mines, Golden, Colo.

LIBBEY, WALDO M., Instructor in Electrical Engineering, University of Maine, Orono, Maine.

LOEBS, WILLIAM F., Instructor in Physics, University of Detroit, Detroit, Mich.

LONGHOUSE, ALFRED D., Professor and Head, Department of Agricultural Engineering, West Virginia University, Morgantown, W. Va.

LYON, DANIEL R., Mechanical Engineer, Construction Department, International Harvester Company, 180 N. Michigan, Chicago, Ill.

LYON, GEORGE B., Instructor in Civil Engineering, University of Minnesota, Minneapolis, Minn.

MAJUMDA, MANOJKUMAR, Architect and Civil Engineer, Shilpa Bitan, P. O. Rehabari, Dirugarh, Assam. F. L. Bishop, N. McKenry.

MANSON, PHILIP W., Associate Professor of Agricultural Engineering, University of Minnesota, University Farm, St. Paul, Minn.

McCROCKLIN, ANDREW J. J., Assistant Professor of Electrical Engineering, University of Texas, Austin, Texas.

McDONALD, CLARENCE T., Instructor in General Engineering Drawing, University of Illinois, Navy Pier, Chicago, Ill.

MELVILLE, THOMAS J., Chief Instructor in Refrigeration, Milwaukee School of Engineering, Milwaukee, Wis. S. A. Eng, C. O. Werwath.

MIEKLE, G. STANLEY, Director, Research Relation with Industry, Research Director, Purdue Research Foundation, Purdue University, Lafayette, Ind.

MIKULASCHEK, W., Librarian, Bibliotheque de l'Ecole Polytechnique Federale, Service de Documentation, Wartstrasse 14, Zurich 7, Switzerland.

MOLD, HOWARD P., Staff, Industrial Relations Dept., Mead Corporation, Chillicothe, Ohio. E. W. Johnson, A. O. Lee.

MOLINA, EDWARD C., Special Lecturer in Mathematics, Newark College of Engineering, 141 Dodd Street, East Orange, New Jersey.

MOREY, LESLIE G., Vice President, Chicago Technical College, 2000 S. Michigan Avenue, Chicago, Ill.

MULLIGAN, JAMES E., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass.

MURPHY, JOHN H., Professor and Head, Law Department, Milwaukee School of Engineering, Milwaukee, Wis.

MURRAY, WILLIAM M., Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

MYERS, EDWIN D., Assistant Professor of Civil Engineering, Mississippi State College, State College, Miss.

NOREN, OSCAR B., Instructor in Engineering Drawing, University of Detroit, Detroit, Mich.

OBERZIL, EDWARD W., Instructor in Engineering Drawing Dept., Case Institute of Technology, Cleveland, Ohio. O. M. Stone, W. E. Nudd.

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